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The Madeira-Mamoré Railway.

By JOHN Y. BAYLISS,* M. Am. Soc. C. E.

The purpose of this railway is to furnish a transportation route around a series of falls and rapids in the Madeira and Mamoré rivers, the only obstructions in a long navigable waterway, reaching from the Atlantic Coast well up into Bolivia. When completed it will be an isolated line of comparatively short extent, and, being remotely situated in the heart of the South American Continent, it is quite likely to remain isolated for some years to come. The route lies in an almost uninhabited country and, except for short distances back from the water courses, unexplored.

It is expected that the first earnings of the railway will be derived from shipments of rubber and of other virgin products of Bolivia and Brazil. But its great utility will come to the Republic of Brazil in opening up a section of its wide domains, which is at present little known, and to the Republic of Bolivia in completing its commercial access to the Atlantic seaboard.

A brief description of the Amazon and Bolivian waterways is necessary to a comprehensive idea of the enterprise. The rivers of northern Brazil, on account of their size and depth, afford unparalleled facilities as commercial routes, and have been used as such for a number of years. This is witnessed by the fact that Brazil has declared open to ships of all nations the Amazon River and its navigable tributaries. Excepting two small railroads in the State of Pará there is not a railroad in the whole of this vast region, the Madeira-Mamoré being the pioneer. Ocean vessels drawing 20 ft. can ascend the Amazon at all seasons of the year and during high water, from December to May, they can come up the Madeira River as far as Santo Antonio Falls.

This is the first of a chain of falls and rapids reaching from Santo Antonio on the Madeira to Guajará-merim on the Mamoré, a distance by the windings of the river of about 240 miles. In this section there are 19 declivities ranging from one to eight meters in height. These declivities, with one or two exceptions, are more properly rapids than falls. The voluminous waters of the Madeira plunge down over granite ledges and through groups of large granite boulders. The turbulent water is seldom more than a kilometer in extent.

Between the rapids the rivers present stretches of deep water, through which large canoes of about ten tons burden, called "bateloes," can be propelled with paddles. At the rapids these boats are unloaded of their cargo and boat and cargo transported around the rapids by hand, a prodigious task. After passing Guajará-merim the Mamoré River and its numerous tributaries can be navigated by small steam craft and "bateloes" for many miles of their courses. These rivers reach out fan-like; the Guaporé into Brazil, the Mamoré toward Trinidad and Santa Cruz in Bolivia and the Beni, which rises near Lake Titicaca. The Beni River, perhaps the most prominent of all the affluents of the Madeira, comes into it below the Falls of Guajará-merim and has itself a large tributary, the Madre de Dios. The Abuná from the west and the Mutum-Paraná and Jaci-Paraná from the east, join the Madeira between Santo Antonio and Guajará-merim.

These rivers drain a large area watered by tropical rains, and unite to form the Madeira River, which, below the Falls of Santo Antonio, is in appearance larger than the lower Mississippi. The maximum discharge of the Madeira below the falls has been estimated to be 1,400,000 cu. ft. per second. The annual fluctuation between high and low water in the Madeira at Santo Antonio is about 50 ft. From December to May is what is known as the wet season, the river reaching its maximum stage during February and March. The maximum monthly rainfall is about 20 ins., and the annual rainfall about 95 ins.

Along the Madeira River and the lower reaches of all its affluents, the vegetation is a thick virgin forest, containing many varieties of large trees, some of them hardwoods, and a dense tangle of smaller trees, vines and undergrowth. Along the water courses in this forest are found the native Brazilian rubber trees, which furnish the best of the market product known as Pará rubber. Rubber trees are found more or less along all the affluents of the Amazon, but the Juruá, the Purus and the upper Madeira are the sources of the largest part and the best grade of the Brazilian output. About 35,000 tons of "seringa" (high-grade rubber) is exported annually from the Amazon and its tributary rivers, representing more than $60,000,000 in market value.

TYPICAL ENGINEERS' CAMP ON THE MADEIRA-MAMORÉ RY. SURVEY; BRAZIL.

Among the early explorers on the Madeira was a Bolivian Governor of the Province of Mojó, José Augustin Palacios, who, in 1846, descended the Madeira to Santo Antonio, located the course of the river by astronomical observations and made sketch maps of the falls and rapids, showing the route taken by canoes in ascending and descending the river. In 1851-52, Lieutenant Gibbon, of the United States Navy, acting under instructions from the Secretary of the Navy, made a tour of exploration from Tarma to La Paz in Bolivia and via the Mamoré and Madeira to the Amazon and thence to the Atlantic coast. In his report, published by the House of Representatives (Executive No. 53, 33d Congress, 1st Session) he gave valuable information in regard to the falls of the Madeira, containing a map of the river with soundings and various hydrographic and descriptive data, with some suggestions as to a practical transportation route around the falls.

In 1867 Brazil, then an empire, desiring to improve this part of her domains, sent an expedition under a German engineer, Franz Keller, to explore and map the Madeira River and make a

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report on the advisability of a route around the falls. He published an account of his journey under the title "The Amazon and Madeira Rivers" (Chapman & Hall, London, publishers). Keller cosidered a railroad to be the most suitable method of passing the rapids.

The railway, however, received its first real impetus from Col. George Earl Church, M. Am. Soc. C. E., an American engineer and explorer, to whom is due the credit for developing the project. In 1869 and 1870 he secured concessions from Bolivia and Brazil to operate a line of steamers on the Bolivian rivers and to build a railway around the falls of the Madeira and Mamoré in Brazilian territory. Col. Church contracted with an English firm, the Public Works Construction Co., to locate and build the railway. This company made extensive surveys during 1872-3, but finally threw up the proposition without having done any actual construction, at the same time involving the Madeira-Mamoré Company in litigation in London.

In spite of reverses, Col. Church then contracted with P. & T. Collins, of Philadelphia, to do the work, and these gentlemen started actively on the enterprise in 1878. An account of their

Map of South America Showing Location of Madeira-Mamoré Ry.

masterful efforts, of the struggle against hardships and obstacles, of the work they accomplished and of their final failure, is remarkably well told by one of the engineers of that party in "Recollections of an Ill Fated Expedition to the Headwaters of the Madeira and Mamoré Rivers" (Lippincott & Co.*) In the end the lawsuits in England and the lack of support from the Bolivian Government prevailed against Col. Church, his company was dissolved and he was forced to give up the project in which he had expended eleven years of time and energy.

In 1882 the Empire of Brazil appointed a commission under G. A. Morsing and Julio Pinkas to survey and report on the cost of a railroad from Santo Antonio to Guajará-merim. This commission made surveys of the route during 1883-84, but nothing further was done towards consummating the project until the Treaty of Petropolis between Bolivia and Brazil was effected in 1904. This treaty was an amicable arrangement of a boundary dispute, and among the terms was a payment of £2,000,000 by Brazil to Bolivia, the acknowledgment of the Acre territory as a part of the Republic of Brazil and the stipulation that Brazil should build the Madeira-Mamoré Railway.

*Engineering News, Oct. 17, 1907.

In 1906 a contract to build the road was made by Brazil with Joaquim Catramby, Civil Engineer, who transferred his contract rights to the present Madeira-Mamoré Ry. Co., which company is organized under the laws of the State of Maine. The railway is to be the property of the Brazilian Government. The company has the contract to locate and design the railway as well as to construct it, the work being paid for at unit prices. In February, 1909, the railway was leased by the Brazilian Government to the company for operation when completed.

Porto Velho, on the Madeira River, is the lower terminus, about seven kilometers below Santo Antonio. Here the river makes a wide bend to the left, leaving a cove on the right or east bank of the river. Deep water is found close in shore at this place, so that it affords suitable natural facilities for shipping and admits of an adequate arrangement within reasonable cost. The bank here is nearly level flat at about high water level for about 800 meters in length and 150 meters in width, which flat has been selected for the terminal tracks and works.

Surrounding this flat are hills that rise from 10 to 30 meters above it, which are now partially occupied by the railway company for offices, dwellings and administrative purposes and later will prove well adapted to the development of a small city, that is likely to spring up around a railway terminal. Of the other terminus of the railway (Villa Church) little can be said at present, except that it will be near the Falls of Guajará-merim, the last rapids in the chain. Of the present organization hardly a dozen men have ever ascended the river as far as Guajará-merim, and those who have can tell of the place no more than can be seen from the river. The distance from Porto Velho to Guajará-merim by the probable route of the railway is about 340 kilometers.

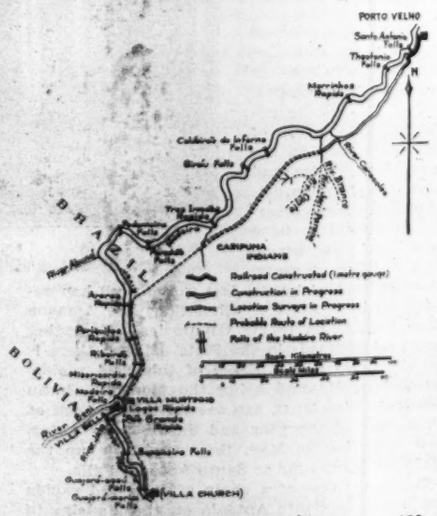
The general conception of the Amazon basin is that of a low flat country, but the topography along the Madeira River is quite different. In many places the ground is broken and cut by many tropical streams ranging in size from a small draw that will pass through a pipe or box culvert to an extensive river 150 meters in width. Occasionally the hills rise 100 meters above the level of the river, and as might be expected these are found in the neighborhood of the rapids or declivities in the course of the Madeira. In passing through these rough places some heavy cuts and fills are encountered on the line and the basic granite rocks are sometimes found in the excavations. Overflow sloughs or swamps called "igapos" occur in places along the route and have already caused considerable trouble on account of the soft bottom and subsidence of structures and embankments built through them.

Of the river crossings the two largest are the Jaci-Paraná and the Mutum-Paraná. The steel for the former bridge has been ordered and consists of one 83-meter pin-connected through truss and two 24-meter through lattice spans. Numerous other smaller rivers are provided for by through and deck lattice spans and plate girders. The masonry for all the bridges is expected to be of concrete, as no satisfactory building stone convenient to the structures has been found on the line of the railway already surveyed.

The survey methods are those generally in vogue on all the railways in the United States,

TYPICAL WORK ON HEAVY GRADING.

but the limitations to reconnoissance and the extent of preliminary lines necessary present conditions decidedly unique. Nowhere along the route yet surveyed, can any conception of the country be had in advance of transit or compass party. In fact it is quite impossible at any time to penetrate the forest without actually cutting a trail along which progress can be made. Each



Sketch Map of the Madeira-Mamoré Ry., May, 1909.

party requires a force of 30 or 40 trail cutters and camp builders. The result is a skeleton of many experimental lines from which the topography of a wide area must be developed and

TYPICAL CONSTRUCTION CAMP.

STUMPS IN A LIGHT CUTTING.

ONE OF THE GIANT TREE TRUNKS.

DRIVING A PILE TRESTLE.

ROOT BUTTRESSES OF A TROPICAL TREE.

TYPICAL ROADBED WITH CONSTRUCTION TRACK.

VIEWS ON THE LINE OF THE MADEIRA-MAMORÉ RY., BRAZIL.

mapped before a choice of route can be made with any certainty of approximating the best line. A locating engineer with a genius for judging country by eye would find this particular talent of little service to him here.

The Brazilian forest here affords nothing to support life except "castanhas" or Brazil nuts and occasionally wild game. The men in location parties are, therefore, dependent for subsistence on the storehouses in Porto Velho, and these in turn are kept stocked by shipments of foodstuffs from the United States and Europe and from other more productive parts of Brazil.

CANOES USED IN TRANSPORTING MAIL AND SUPPLIES TO THE SURVEY CAMPS.

HAULING A BATELAO ACROSS A PORTAGE AROUND MADEIRA RIVER FALLS.

These provisions are sent up the river in "bateloes" to the neighborhood of the parties and thence packed inland by men or mules. The metric system of measurements is used, the degree of curve corresponding to a 20-meter chord. The maximum gradient is 1%, with maximum curvature of 6°—equivalent to about 9° with 100-ft. chord.

A CANOE PARTY OF INDIANS ON THE MADEIRA RIVER.

The authorized width of roadbed is 4.2 meters for cuts and 4.0 meters for embankments. The gage of the track is one meter. Grading is done by casting into low embankments from side borrow, or with wheelbarrows. Carts and mules are used in some cases, but most of the haul is made with small Decauville dump-cars. A 45-ton Bucyrus steam shovel is used in the larger excavations. Small openings for drainage are provided with vitrified pipes and concrete culverts. The use of vitrified pipes, however, is limited because the Government engineers prefer not to use pipes of more than 18 ins. diameter.

The rail is of French manufacture, 25 kilos to the meter, of which enough for about 240 kilometers of track has already been delivered at Porto Velho. The company has now in service on construction three 45-ton Mogul locomotives, made by the Baldwin Locomotive Works, 40 20-ton flat cars and 10 20-ton box cars. An order has been placed for 60 more flat cars, two consolidation locomotives and another steam shovel. Authority has also been requested from the Brazilian Government to purchase 6 additional locomotives and 24 box cars.

The forests contain some varieties of hardwoods which would be suitable for permanent structures were it not for the ravages of insects. A species of white ant, called locally "cupin," appears to be the most destructive. These insects seem to attack timber bridges more than they do the timber ties, which are partially buried in the ground. They work in armies building nests and artificial tunnels on the outside of bridge timbers and working into the heart of the timber from the ends. Although the largest of the "cupins" yet observed is no longer than ¼-in., so rapid and destructive is their action that the life of a timber bridge can hardly be considered more than two years. Frequently stringers and timbers whose ends butt together, appearing perfectly sound on the outside, are found in an incredibly short time to be so thoroughly honeycombed by this energetic little creature as to become unsafe members in a bridge or other important structure. No satisfactory method of preventing the action of "cupins" has yet been found here. Kerosene poured over a nest or into a tunnel will kill the insects within. The timber can then be scraped clean, but another army is soon at work again.

Timber bridges have been built at various places to expedite the work and get the rail head to the front, but for permanency, steel and masonry are the only materials suitable. A considerable quantity of pine lumber from the Southern States is being used for building purposes in Porto Velho. The experience up to date indicates that the insects do not attack this resinous wood, but not sufficient time has yet elapsed to prove conclusively that pine lumber will withstand their ravages. Ties of native timber used in the track, either on account of the vibrations of passing trains or the partial covering of earth, resist the "cupin" more successfully.

To the end of July, 1909, about 130 kilometers of definite location has been made. Eighty-eight kilometers of line is under construction. Track has been laid for the first 50 kilometers. A telegraph line is extended simultaneously with the advance of construction camps and is at present used for telephone service from Porto Velho.

At Porto Velho a tract 1,000 meters long by 500 wide has been cleared and subdivided for the terminal works and town site. Grading for the railroad yard is partly completed. Concrete foundations on piles are well under way for the terminal shops, which are to be of steel. Much of the shop machinery is now on the ground. In addition to the headquarters offices and dwellings, the company has installed and in operation at Porto Velho a saw mill, an ice and cold storage plant, a steam laundry, a commissary and several large warehouses. For water supply a small concrete reservoir has been built over a spring and the water is pumped into elevated wooden tanks, which supply the various buildings and dwellings. A deep well for permanent supply, free from surface drainage, has reached a depth of 200 ft. and boring still continues. A sewer system is to be built of vitrified pipe. Preparations are being made to erect an electric light plant already delivered in Porto Velho.

A suitable design for a dock at Porto Velho has been a source of much study. The bank of the river for a considerable depth is composed of river deposits which tend to cave with the annual fluctuations of the river. During high water immense cedar trees from the Bolivian rivers are carried past Porto Velho on a swiftly running current, and the rise and fall of nearly 50 ft. in the river adds to the difficulties. For the present a timber dock on piling has been constructed a little above high water level with a choice of building an incline running along the bank of the river to reach low water, or of extending the present dock directly out into the river and using hoisting cranes.

All labor on the work is brought here from other parts, there being no fixed population on the Madeira River. The present force consists of Brazilians from the Coast States, "Gallegos" from Cuba, negroes from Jamaica and Barbados and Spanish and Portuguese directly from Europe. A trial shipment of German laborers is also enroute to Porto Velho. Most of the grading work is done by station contracts. Tools and accessories are furnished free to station men, and they receive for earthwork three milreis per cubic meter, equivalent to 70 cts. gold per cu. yd. The ordinary day laborers receive eight milreis, or $2.40 gold, per day of 10 hours.

The only suitable construction material found along the route is sand and filler for making concrete and hardwood timber for ties and timber bridges, etc., the latter being of doubtful utility on account of the action of insects, as previously noted. All other materials and supplies, except certain classes of foodstuffs from other parts of Brazil, are imported from the United States and Europe. Freight rates on the Amazon and Madeira rivers, especially the latter, are extremely high. Provisions and small material are shipped by regular lines of ocean and river steamers running up the Amazon as far as Manáos. Near the mouth of the

Madeira, the company has a freight transfer station on the hulk of an ocean steamer anchored in the Amazon River, and has its own fleet of river boats for carrying freight up the Madeira. This fleet consists of a passenger and freight steamer of about 500 tons, four tugs and eight lighters.

Bulky machinery and freight in large lots is delivered at Porto Velho much more economically by chartered steamers, which, during high water, come directly to Porto Velho from the United States and Europe and tie up close enough to discharge their cargoes onto the wharf or into freight cars. During the past high water five of these chartered steamers of about 6,000 tons burden and drawing 16 to 20 ft. of water have been unloaded at Porto Velho. The incident of loaded vessels of such size, safely discharging their cargoes 1,600 miles from the sea, is probably not to be duplicated anywhere else in the world.

The nearest cable station is now at Manãos. The railway company has contracted with the Marconi Wireless Telegraph Co. to establish wireless communication between Porto Velho and Manãos. Work has already been started on the two stations required, one at Porto Velho, the other at Manãos, and it is expected that these stations will be operating by the end of the present year.

The company has built, near Porto Velho, a well-equipped hospital with five large detached wards, four second-class and one first. Each large ward will accommodate 50 patients. There are also several smaller wards for contagious diseases. Malaria and dysentery are the prevailing diseases that require hospital treatment. The medical staff consists of eleven practising physicians and several trained nurses. Medical attention is furnished free to all the employees of the railway.

Some of the prices named in the contract between the Government of Brazil and the railway company are sufficiently unusual to justify mentioning. Surveys are paid for at the rate of $450 per kilometer for preliminary lines and $606 for location; clearing, 280 reis per sq. meter, equivalent to about $340 per acre; grubbing, 1,200 reis per sq. meter, or $1,458 per acre; earth excavation, three milreis per cu. meter, about 70 cts. per cu. yd.; rock excavation, 14 milreis per cu. meter, or $3.25 per cu. yd.; concrete, 95 milreis per cu. meter, or $21.90 per cu. yd.; bridge timbers, 190 milreis per cu. meter, or $136 per 1,000 ft., B. M., etc., etc.

Analysis of the cost of doing the work shows it to be very heavy. Labor must be imported and paid a high wage for work. The salaries of engineers and contractors' employees are about triple those for similar service in the United States. On account of sick days on the work and necessary leaves of absence for recuperation a much larger organization is employed than is usually necessary.

Mr. P. H. Ashmead is the Chief Engineer for the railway company; Mr. F. C. Englesing, Assistant Chief Engineer; Mr. J. M. Robinson, Principal Assistant Engineer in charge of location; and the writer, Principal Assistant Engineer in charge of construction. Messrs. May & Jekyll, of New York, are the contractors. The first 88 kilometers of the railway is to be opened for traffic about the end of 1909, and the entire railway is expected to be finished in 1912.

A DISPOSAL SERVICE for the handling of material excavated at building foundations, building rubbish, ashes from power plants, etc., is being operated by the Chicago Subway Co., which owns a system of some 40 miles of small, deep level tunnels under the city of Chicago. Spurs are run to deep basements or to shafts where the materials are loaded into cars which are hauled by electric locomotives to a disposal station on the west bank of the Chicago River near Madison St. Here there is a shaft, over which are the runways for two electric trolley hoists, each operated by a man riding on the machine. When a car is set at the bottom of the shaft, the body is hoisted up and run out over a dump scow moored alongside the station. The car body is lowered and the bottom released, discharging the contents into the scow. The empty body is then run back and lowered upon the car frame at the bottom of the shaft.

A Suggested Change in the M. C. B. Rules for Freight Car Interchange.*

By WM. BAIRD.†

The railways to-day are confronted with a great many problems, and one of the most important is the prompt delivery of freight to its destination. A great deal of the tonnage any railway carries is destined beyond the line originating it; substantially half of all of the tonnage offered by the patrons for transportation must pass beyond the initial carrier to reach its destination, and much of this interchanged tonnage must be handled by from two to a dozen lines in reaching its journey's end. Upwards of 800,000,000 tons per year come under this head.

This interchange between railways occurs in the commercial centers where congestions are easily caused; where room is always at a premium and where cost of operation is invariably high. Yet, in these terminals, where the minimum of delay produces the maximum of trouble, it is no uncommon thing to see important trains held for hours to get the through cars from connections, only to find that half the cars were refused by the car inspector.

And why? Because a roof-board was broken or a corner knocked off a piece of sheathing, or a wheel had a flat spot that was just to the limit, and had run perhaps 300 miles over the delivering company's line, but as it was just 2½ ins., it must go to the repair track, not of the receiving line, but back to the delivering line, to have a pair of wheels applied, resulting in a delay to the contents of 24 hours. What encouragement is this to the freight agent, who has solicited the shipment, telling the shipper he may be assured of prompt service.

Where is the responsibility? Simply in the M. C. B. rules in saying that if such a defect exists on a car it "may" be rejected, and rejected it is, regardless of the contents. The car is moved from the transfer back to the delivering line yard, put on a track with a lot of other bad order cars, and on the following day is taken to the repair track. In the meantime it may be further damaged in switching, and perhaps the contents as well, and in addition to the delay, the railway company has a claim to pay. All because a car inspector, who, in many cases, does not give a thought in connection with the movement of equipment other than to look for defects as laid down in the M. C. B. rules, has no idea of the responsibility of the railway company to the shipper (and cares less), but just loves to "get even" with the inspector of the delivering line who at some time sent some cars back to his line.

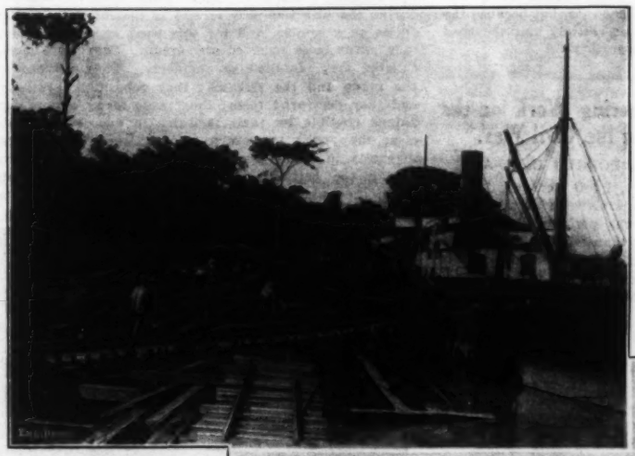
The railways and the business world have outgrown such methods, and I believe we are ready for a change. The Master Car Builders' rules have so great an effect upon the handling of this country's tonnage that the time has arrived for making them conform to the transportation-traffic needs.

At some of our large interchange points local rules have been adopted that keep the loaded car moving forward. When such rules have been in force for any length of time, the roads would not think of returning to the setback plan, but these local rules are not sufficient for the business of the whole country. What is wanted is a rule embodied in the M. C. B. rules, reading something like this: "Loaded cars must be accepted. If not in a safe and serviceable condition, the receiving line shall repair the car or transfer the load." In other words, we must take the load and "run, repair or transfer."

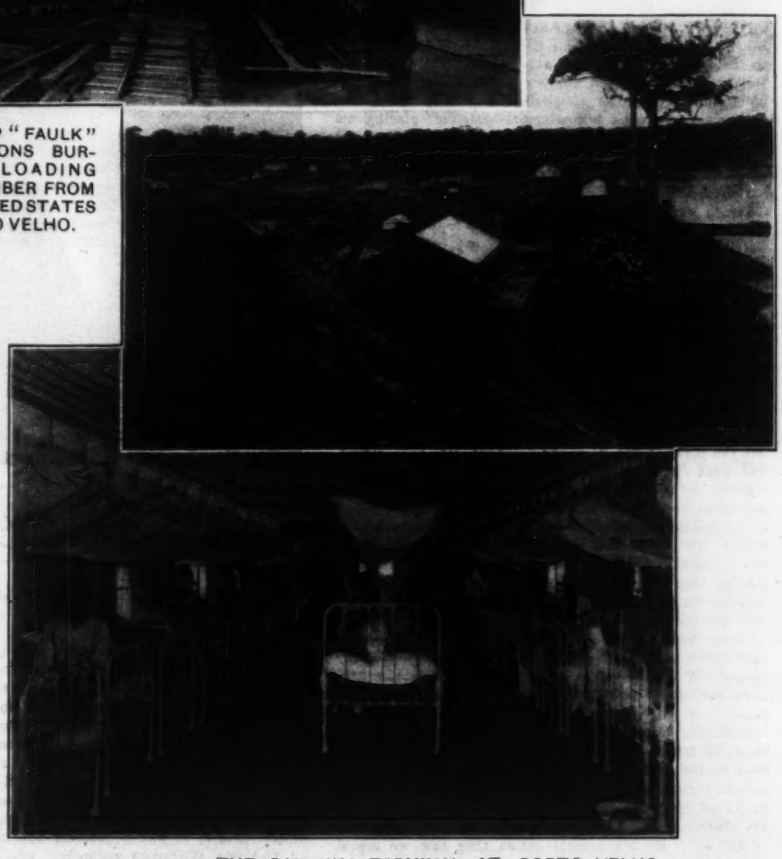
The question of whether the delivering or receiving line should stand the cost of transfer is one that will arise. But let us not allow anything to cloud the issue

*From a paper presented before the Western Railway Club, Chicago, Oct. 19, 1909.

†Shop Superintendent of the Chicago, Burlington & Quincy Ry., Plattsmouth, Neb.



STEAMSHIP "FAULK" (7,000 TONS BURDEN) UNLOADING PINE LUMBER FROM THE UNITED STATES AT PORTO VELHO.



THE RAILWAY TERMINAL AT PORTO VELHO.
INTERIOR OF LABORERS' WARD IN PORTO VELHO HOSPITAL.

or keep us from overcoming the practice of rejecting freight when tendered in interchange between railways.

We frequently see it stated that the margin of profit is too small in the transportation business; that rates should be higher. How, then, can our managements sanction our rules, which not only permit, but require, freight by the thousands of tons to be handled daily without any compensation at all, not toward its destination, but directly away from it, merely because the vehicle which contains the freight needs repairs?

It is bad enough to have any inspectors who will take advantage of the rules. How much worse it is to have rules officially sanctioning the rejection of business after being accepted from the shipper and started on its journey, this rejection by one road after another being due not to any difficulty with the freight rate, but because the vehicle which contains it does not entirely suit the road which is receiving pay for transporting it?

Reminiscences of Engineering Work on the Pacific Railways and in the Civil War.*

By GEN. GRENVILLE M. DODGE,† U. S. A.

In 1851, at the age of 20 years, I left Norwich University, Vt., a military college, as a civil and military engineer. My military training was perhaps of as much or more benefit to me generally than what I had learned of engineering, in the work I had to undertake. It taught me how to command men; it gave me discipline, a respect for authority, obedience to order, loyalty to my country, and an interest in the work of my employer, that it would be impossible for me to have obtained in any other way.

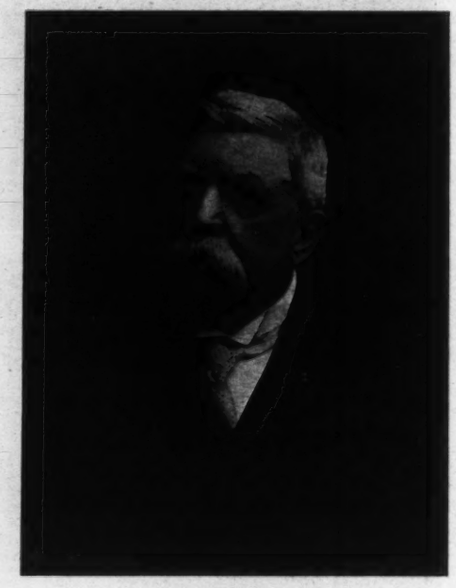
I came West and took an axe-man's place in an engineering party on the Illinois Central Ry., and later went to the Rock Island road as axe-man under Mr. Peter A. Dey, who was division engineer. He was promoted to chief engineer of the Mississippi & Missouri Ry. and took me to Iowa as his principal assistant, placing me in charge of a party in the field, which was a very fine promotion for the limited experience I had. In May, 1853, we crossed the Mississippi River at Davenport and surveyed the first railway line across Iowa. The settlements were then confined almost entirely to the country between Davenport and Iowa City. From Iowa City west to Des Moines there were very few settlers and from Des Moines to Council Bluffs there were none. On reaching the Missouri River, my party was instructed to push west into the great Platte Valley to determine where a road running up that valley would strike the Missouri River. That country then was occupied solely by Indians and there was scarcely a man in my party who had seen an Indian. We crossed the river in a flat boat and I commenced the surveys west from where the city of Omaha now stands.

After I had raised the bluffs skirting the Missouri, I left the party in charge of my assistant, Mr. J. E. House, and went on alone some 25 miles to the Elkhorn valley looking up the country ahead. About noon, I lariated my horse, took my rifle and hid it, and making a pillow of my saddle, lay down to take a rest. I had lost a good deal of sleep and was very tired. I was awakened by the noise of my pony. Jumping up I saw an Indian leading him towards the Elkhorn River. The pony was holding back, being evidently very much frightened at the Indian. I was greatly frightened myself, hardly knowing what to do, but I grabbed my rifle and rushed after the pony and the Indian yelling at the top of my voice. He let the horse go and swam across the Elkhorn out of my reach and I was very glad to see him go.

Returning to my party, I found them camped on the Papillion Creek, with the camp full of Indians and every man in the party cooking or feeding them. I saw that radical action had to be taken or the provisions I had would all be gone. My party was thoroughly armed. I got them together immediately and notified the Indians to get out. By my prompt action they saw we meant business and left us. From that time until I stopped my work on the plains I never allowed the party to have Indians come into camp except with the party's permission. This is the kind of responsibility the young engineer in that day had to take. He was away from anyone to advise with or to lean upon. He was responsible for his party. Its life and safety were in his hands, and in the development of this country the risks taken and the dangers faced have never been told.

From this time until the Civil War, we were engaged in building the railroad to Iowa City, the capital of Iowa, and in making reconnaissance west of the Missouri River for a Pacific railway. It might seem strange to you that although the government spent millions of dollars in examining different routes for the Pacific railway, covering the country between parallels of 32° and 49° (No. Lat.), the reports of which examinations were printed in a dozen large volumes, no examination was made by the government upon the most feasible route across the continent. That was left to private enterprise. Our exploration and reconnaissance, up to 1860 had determined on the 42d parallel, practically the present line of the railway crossing the continent. The detailed surveys had not been made, but the buffalo, the Indian, the fur trader, the telegraph, the pony express, the stage line, and finally the engineer, determined the line, and the road when built followed it.

In 1861 the Civil War came. I went into the service with 600 other civil engineers who were graduates of Norwich University, all of whom became commissioned officers, many of them rising to the highest rank and to the highest command. Their work as civil engineers during the war was only second to that of their military duties as a soldier, and for this work as civil engineers they never have received any credit. They were mostly enlisted men, detailed as engineers. They mapped out the roads and the streams; they rebuilt the railways, and they destroyed them; they made many of our campaigns possible by their facilities in overcoming obstacles; they built temporary bridges; they showed great ingenuity in throwing up temporary entrenchments even during the battles; and they constructed impregnable forts; they were always brave, they never flinched their



Grenville M. Dodge

duty and there is no commander of a division or corps of the army but what appreciated their great and valuable service.

In 1862 I was assigned to the command of the Central Division of the Mississippi with orders to reconstruct the railroad reaching from Columbus, Ky., to Corinth, Miss., for the purpose of bringing supplies to the army then concentrated at Corinth. This line crossed many deep bayous which had been spanned by truss bridges, all of which had been destroyed by the enemy as they retreated. As I looked at the job before me and saw these deep bayous with no foundations and with no possible means of putting in proper abutments, or furnishing proper superstructure, it was a problem appalling to anyone.

I had two Wisconsin regiments, one was commanded by Col. George E. Bryant, who had been a Norwich University cadet and a civil engineer. He commanded a regiment that was raised in the logging camps of Wisconsin. I ordered every engineer, civil or mechanical, or anyone who had had experience in such work in the command, to report to me, and I was astonished to see the number of enlisted men who reported. We held a consultation as to how we should handle this problem, and decided to put the 12th Wisconsin into the woods with their axes (as that was about all the tools we had) and make crib piers for these streams. It was easy work for us to handle the culverts and it was astonishing how soon we built this railway. The log cribs were bolted together by dowel pins made from the iron rods of the destroyed Howe truss bridges. We made stringers 30 and 40 ft. long and sunk our piers to a foundation that would carry our trains.

Within two months we had rebuilt this road, and had put up at each important bridge a blockhouse, so a small force could hold it against almost any enemy. In the celebrated raid of Forrest, where he destroyed most of the bridges south of Jackson, Tenn., when he came to the block houses in our territory, he was repulsed at every point. This drew the attention of Gen. Grant and he immediately ordered block houses built at every bridge on the railways within his command.

The ingenuity of these young engineers in putting up these bridges, blockhouses and stockades; in overcoming every difficulty, and the interest they took in their work soon convinced me that all that was needed in our army for effective construction (or destruction) of a railroad was proper organization of the material in hand. The mechanics in the command put the locomotives and cars "on their feet" and ran them, so that virtually the young engineers and young mechanics in that command "re-created" the road.

This drew the attention of Gen. Grant and as long as my corps was under his direction or under that of Gen. Sherman, whenever there was any destruction or reconstruction or bridge work of any kind to be accomplished, it fell to us, until the Pioneer Corps of the 16th Army Corps had as good a reputation for its mechanical work as it had for fighting ability.

In the fall of 1863 I received orders from Gen. Grant to rebuild the railway from Nashville to Decatur. The entire line had been destroyed. There were several truss bridges crossing Duck River and also some very high trestles, some of them being 125 ft. high. And there was the Tennessee River to be crossed. Gen. Grant was very anxious to have this road built rapidly in order to feed his army at Chattanooga, which was in great distress, and Sherman told me the quicker I built the road the sooner I would get something to eat for my command. We were entirely away from any base of supplies, living off the country, and had been doing so during our entire march.

The work of the young engineers in building this road is a good deal better stated by Gen. Grant than I can tell you, and I will read what he says:

> I gave an order to Sherman to halt Gen. G. M. Dodge's command, of about 8,000 men, at Athens, and subsequently directed the latter to arrange his troops along the railway from Decatur north towards Nashville, and to rebuild that road. The road from Nashville to Decatur passes over a broken country, cut up with innumerable streams, many of them of considerable width, and with valleys far below the roadbed. All the bridges over these had been destroyed, and the rails taken up and twisted by the enemy. All the cars and locomotives not carried off had been destroyed as effectually as they knew how to destroy them. All the bridges and culverts had been destroyed between Nashville and Decatur, and thence to Stevenson, where the Memphis & Charleston and the Nashville & Chattanooga roads unite.
>
> Gen. Dodge was an experienced railway builder. He had no tools to work with except those of the pioneers: axes, picks and spades. With these he was able to intrench his men and protect them against surprises by small parties of the enemy. As he had no base of supplies until the road could be completed back to Nashville, the first matter to consider after protecting his men was the getting in of food and forage from the surrounding country. He had his men and teams bring in all the grain they could find, or all they needed, and all the cattle for beef, and such other food as could be found. Millers were detailed from the ranks to run the mills along the line of the army. When these were not near enough to the troops for protection they were taken down and moved up. In like manner, blacksmiths were detailed and set to work making the tools necessary in railway and bridge building. Axemen were put to work getting out timber for bridges and cutting fuel for locomotive use when the road should be completed. Car-builders were set to work repairing the locomotives and cars. Thus every branch of railway building, making tools to work with, and supplying the workmen with food, was all going on at once, and without the aid of a mechanic or laborer except what the command itself furnished.
>
> Gen. Dodge had the work assigned him finished within 40 days after receiving his orders. The number of bridges to rebuild was 182, many of them over deep and wide chasms; the length of road repaired was 102 miles.

When we had flanked the enemy out of the Kenesaw mountain line, our extreme right rested on the Chattahoochee River some miles southwest of the railroad crossing. Gen. Sherman came to my headquarters and told me he proposed to flank Atlanta by moving his army by the left. We all supposed he was going by the right. He said to me there was a place called Roswell Shoals on the Chattahoochee where he desired to cross a portion of his army. He said the shoals were shallow and described them to me, asking me how long it would take for my command to build a bridge over that stream. He stated his engineers had told him it was a big job. I looked the matter over and told him about a week. He seemed astonished and left me, but in a very short time I received orders to move with my corps as rapidly as possible to Roswell, some 31 miles away. We made the march without stopping except for resting our men, and reached there Sunday about noon.

I found that Roswell contained several large factories that had been supplying material to the enemy, and that if I had the timber in these factories I could soon put up a bridge across the river. The enemy occupied the opposite side, and one of the most inspiring sights I ever saw was when I ordered the celebrated Ohio brigade to ford the river and take the opposite bank. There they reformed, and charging, soon cleared the works. My pioneer corps now was very effective. It was about 1,500 strong and was organized into squads with a civil or mechanical engineer at the head of every

*Abstract of an address delivered at the annual dinner of the Western Society of Engineers, at Chicago. The address is printed in full in the "Journal" of the society for February, 1900.

†1 Broadway, New York City.

squad. Everyone knew exactly what his duty was, just where and how to go to work, and all I had to do was to give the orders. I immediately gave the order to pull down the cotton factories that would furnish lumber and on Monday morning you could stand on the bank and see the bridge "walk up," so that Wednesday at noon, in three days, I notified Sherman that it was ready for crossing. He was astonished and sent a proper tribute to the young engineers for their quick work. My official dispatch to him reads as follows:

A footbridge 710 ft. long was thrown across the river and from Monday noon, July 10, until Wednesday night, July 12, a good substantial, double track, trestle road bridge, 710 ft. long and 14 ft. high, was built by the pioneer corps from the command.

Sherman was always profuse in his praise of the young engineers of the army that were continually at work gathering up information for us. I had a very efficient corps for that work under me and Sherman often wrote to me, thanking me for what I had been sending him, saying he would store it up for future use. This information concerning the streams, the villages and roads was compiled at his headquarters, printed on cloth and a copy sent to each corps or division commander and was of great service to us.

There was one young man detailed to me, who afterwards became a very noted engineer, Marshall S. Hurd, who enlisted from Muscatine, Iowa, in the 2d Iowa Infantry. I soon discovered that he was a genius and of great ability as an engineer, of excellent practical judgment and very brave. We all tried to get him promoted and a commission given him so he could command officers and men, but we never could accomplish it. However, he virtually got to the head of the pioneer corps of the 16th Army Corps, and the boys all dubbed him "Major"; and he was known all through the war as Major Hurd, not only by the men of my corps but by the others.

When he would take his pioneers out to build entrenchments, he never allowed them to run when the skirmish line of the enemy made an attack, which was often, but they would lay down their implements where they were, take their rifles, and fight it out themselves. He was very resourceful in an emergency. After the war he was connected with us on the Union Pacific and was at the head of some of the surveys both on the Union Pacific and Southern Pacific routes, fought battles with the Indians, and when the Canadian Pacific road was built, he was sent for and went to that work, running some of the important lines over the mountain division. He was the most modest, retiring, unassuming man I ever met. He now lies buried in the cemetery at Denver with a monument raised to his memory and upon it a proper tribute to his great work. I mention him only as one among hundreds of enlisted men who performed such duties.

In May, 1866, I returned to the Union Pacific Ry. Mr. Dey having resigned as Chief Engineer, I was appointed to that office. Almost the first dispatch when I reached Omaha was one from the commander at Fort Collins (he had been under me during my command of that country), telling me that a young man by the name of J. M. Eddy had brought in an engineering party which had had a fight with the Indians and that the chief of the party had been killed. I instructed him to have his party meet me on Lodge Pole Creek, as I was just starting west over the line. I found that Eddy was a young soldier, who had enlisted in the 13th Illinois Infantry, and had served under me in the war. In this fight, after the chief had been killed, he rallied the rest of the party and brought it in safety to the military post.

He stayed with me during the construction of the Union Pacific and also the Southern Pacific railways. At one time he was General Manager of the Southwestern System. He died in the service. I speak of him only as an example of what the engineers during 1866-67-68-69 had to face. The line was covered by engineers from the Missouri River to the California state line, and every party was thoroughly armed and had escorts, but many of our best men were killed.

In 1867, when I was crossing the plains and reached the North Platte River near where Rawlins now stands, Percy T. Brown, a very capable engineer in charge of the division from the Platte to the Green River, in reconnoitering that country, discovered that the divide of the continent, where we were crossing, was a basin of about 100 miles north and south, and 80 miles east and west. His party got into it but could find no streams leading out of it to the west. He took eight men for his escort to make an exploration through that basin. Near its south rim he encountered 300 Sioux Indians who were on the war path. He immediately took possession of an elevation in the basin and there from noon until nearly dark, fought off those Indians. Just before dark, a fatal shot from an Indian hit Brown in the abdomen. He begged the men to leave him and save themselves, but the soldiers refused to do so. They turned loose their horses, and as soon as the Indians obtained them they went away. These soldiers then made a litter of their carbines and through the tall sage brush for 13 miles that night carried Brown to Laclede stage station thinking to save him, but he died soon after reaching the station.

One of the great problems that confronted our early surveys was the crossing of the Black Hills, a spur of the Rocky Mountains. There was no trouble after reaching the summit of the range, in descending the west slope into the Laramie plains, but the country on the east dropped off rapidly, and there was no stream or divide that we could find that was practicable for a 116-ft. grade though the engineers had examined nearly every stream and every divide. The divides from the summit down, for a long distance were favorable, but just as we came to the division of the granitic and sedimentary formations, there would be a drop of 500 ft. in 1,000 and we could not find supporting ground to hold our grade, to overcome this great fall.

In 1865 as I was returning from the Yellowstone country, after finishing the Indian campaigns, I took my command along the east base of the Black Hills following up the Chug Water and so on south, leaving my train every day and going on to the summit of the Black Hills with a view of trying to discover some approach from the east that was feasible. When we got down to the crossing of the "Lodge Pole," I knew that Indians were following us, but I left the command with a few cavalrymen and guides with a view of following the country from the Cheyenne Pass south, also leaving strict orders with the command that if they saw smoke signals they were to come to us immediately.

We worked south from the Cheyenne Pass and around the head of Crow Creek, when I looked down into the valley and saw there was a band of Indians who had worked themselves in between our party and the trains. I knew it meant trouble for us, they were either after us or our stock. I therefore immediately dismounted, and giving our horses to a couple of men with instructions to keep on the west side of the ridge out of sight and gunshot, if possible, took the ridge between Lodge Pole, Crow Creek and Lone Tree Creek keeping upon it and holding the Indians away from us; our firearms were of such long range that when they came too near to us they were in danger as our best shots showed them.

We made signals for our cavalry but they did not seem to see them. It was getting along in the afternoon as we worked down this ridge, and I began to discover we were on an apparently very fine approach to the Black Hills, and one of the guides has stated that I said: "If we save our scalps I believe we have found a railway line over the mountains." About 4 o'clock, when the Indians were preparing to take the ridge at our front, the cavalry saw our signals and soon came to our rescue, and when we reached the valley I was satisfied that the ridge we had followed was one which we could climb with a maximum grade within our charter limits and with comparatively light work.

As soon as I took charge of the Union Pacific I immediately wired to Mr. James A. Evans, who had charge of that division, and who had been working on this mountain range for nearly a year, describing this ridge to him as I had thoroughly marked it by a lone tree on Lone Tree Creek and by a very steep cut butte on Crow Creek, and a deep depression in the ridge where the granitic and sedimentary formations joined. He immediately made an examination and discovered a remarkably direct line, with only a 90-ft. grade, reaching from the summit to the valley of Crow Creek near where Cheyenne now stands, and this summit I immediately named for my old commander, Gen. Sherman. The Union Pacific Ry. is now constructed over this line and it is one of the two 80-ft. grades now left on the Union Pacific which they were unable to reduce during the reconstruction of the road.

The success of the engineers in the surveying and constructing of this road was due mostly to their natural courage and ability. One of the instructions given a party when put into the field was, that the chief of the party must absolutely command it, and at all times be ready to fight. Another was, the importance of never slacking their vigilance, no matter where they were, and never being off their guard. All those who obeyed these orders, generally took their parties through, but those who did not, were soon relieved in the field or were killed by an attack of Indians. Then, again, these engineers were all men of ability. Every one of them, as far as I know, has risen to distinction either in his own profession or in some line of business.

I know of only two of the chiefs of parties who are still living. One is the engineer who first undertook to locate the line across Salt Lake where the road is now built. When I sent him out I gave him Capt. Stanbury's soundings. The Mormons built him a boat, he put his party into it and while he was making the soundings of the lake, a terrific gale came up that swamped his boat and came very near drowning him and his party. He reported to me that the lake was 14 ft. higher than when Stanbury sounded it in 1849, and it is a singular fact that it was then at its highest known level, for from 1870 until 1900 it continually fell. When the Union Pacific built the line across the lake it was 11 ft. lower than when the original survey was made. The depth of the lake, the weight of the water, and the cost of building was beyond us, and we were forced north of the lake and had to put in the high grades crossing Promontory Ridge.

The organization for the construction of the Union Pacific Ry. was purely upon a military basis. Nearly every man working upon it had been in the Civil War; the heads of most of the engineering parties and all of the construction forces were officers in the Civil War. The chief of the tracklaying force, Gen. Casement, had been a division commander in the Civil War, and at any moment I could call into the field a thousand men well officered, ready to meet any crisis or any emergency. There was no law in the country, and no court. We laid out the towns, officered them, kept peace and everything went on smoothly and in harmony. Two or three times at the end of our tracks a rough crowd would gather and dispute our authority, but they were soon disposed of.

The work of the engineers on the Union Pacific was a very masterful one. In the beginning they had no reliable maps or any knowledge of the country, and they explored it until they obtained a line across the country over which one locomotive, then as well as now, could haul as many cars over the line as two engines on any other of the transcontinental lines. My yearly report upon the completion of the road describes better perhaps than I can now, what they accomplished and is as follows:

They occupied the country extending from the Missouri River to the California state line, and covering a width of 200 miles, north and south, and on the general direction of the 42d parallel of latitude; some 15,000 miles of instrumental lines have been run, and over 25,000 miles of reconnaissance made.

In 1863 and 1864, preliminary surveys were inaugurated, but in 1866 the country was systematically occupied; and day and night, summer and winter, the explorations were pushed forward through dangers and hardships that very few at this day appreciate, as every mile had to be run within range of the musket, as there was not a moment's security. In making surveys, numbers of our men, some of them the ablest and most promising, were killed; and during the construction our stock was run off by the hundred, I might say by the thousand. As one difficulty after another arose and was overcome, both in the engineering, running and construction departments, a new era in railway building was inaugurated.

Each day taught us lessons by which we profited for the next, and our advances and improvements in the art of railway construction were marked by the progress of the work, 40 miles of track having been laid in 1865, 260 in 1866, 240 in 1867, including the ascent to the summit of the Rocky Mountains, at an elevation of 8,235 ft. above the ocean; and during 1868 and to May 10, 1869, 555 miles, all exclusive of side and temporary tracks, of which over 180 miles were built in addition.

At Promontory Point, north of Salt Lake, Utah, on May 10, 1869, gathered there from the Atlantic and the Pacific the men who made possible this great work, who threw their fortunes, their credit and their reputation into it. They were the few bold spirits who backed the enterprise with their fortunes and their credit. They spent many millions to meet the clamor and demand of our whole nation for speed, and constructed a railway 2,000 miles long in three years, when their own interests, their charter and the government allowed them ten years to complete the work. So far as it was possible for man to see, as a commercial problem, it had few, if any, advocates. It was simply considered a military necessity. Some day these men will stand in civil life like our leaders in the Civil War. The engineers and the workmen stood in groups watching the preparations for the driving of the golden spike which should tie together with iron bands this continent. The locomotives from the east and from the west were run together and each engineer broke a bottle of champagne on their comrade's machine, and a great glorification of the event was celebrated all over the country.

How well all did their work I leave to the distinguished commission of engineers appointed by Act of Congress to examine, review and report upon the completion of the Union Pacific Ry., which reported as follows:

Taken as a whole, the Union Pacific Ry. has been well constructed. The general route for the line is exceedingly well chosen, crossing the Rocky Mountain ranges at some of the most favorable passes on the continent, and possessing capabilities for easy grades and favorable alinements unsurpassed by any other railway line on similarly elevated grounds. The energy and perseverance with which the work has been urged forward, and the rapidity with which it has been executed are without parallel in history. In the grandeur and magnitude of the undertaking, it has never been equaled, and no other line compares with this in the arid and barren character of the country it traverses, giving rise to unusual inconveniences and difficulties, and imposing the necessity of obtaining almost every requisite of material, of labor, and supplies for its construction, from the extreme initial point of its commencement.

G. K. Warren, Brevet Major-General, U. S. A.,
J. Blickensderfer, Jr., Civil Engineer,
James Barnes, Civil Engineer.

In the last five years the Union Pacific and the Southern Pacific have been virtually reconstructed, under the able management of Mr. Harriman. The Union Pacific in bringing its grades to a maximum of 47 ft. per mile (excepting the 80-ft. grade rising the mountains from the east, at Cheyenne and the 80-ft. grade rising the Wahsatch range west, from the town Echo), and in shortening the line some 30 miles, has spent almost, if not fully as much money as it took to construct the road. The distinguished engineer (Mr. Berry) who had

charge of that work is now the Chief Engineer of the Rock Island system and he pays this tribute to the engineers and builders of the original line:

It may appear to those unfamiliar with the character of the country that the great saving in distance and reduction of grade would stand as a criticism of the work of the pioneer engineers who made the original location of the road. Such is not the case. The changes made have been expensive and could be warranted only by the volume of traffic handled at the present day. Too much credit cannot be given Gen. G. M. Dodge and his assistants. They studied their task thoroughly and performed it well. Limited by law to a maximum gradient of 116 ft. to the mile, not compensated for curvature, they held it down to about 90 ft. per mile. Taking into consideration the existing conditions 35 years ago; lack of maps of the country, hostility of the Indians, which made U. S. troops necessary for protection of surveying parties, difficult transportation, excessive cost of labor, uncertainty as to probable volume of traffic, limited amount of money and the necessity to get the road built as soon as possible, it can be said, with all our present knowledge of the topography of the country, that the line was located with very great skill.

Since the public statements of Mr. Harriman and this tribute by Mr. Berry we have heard no more talk of the unnecessary miles of road that were built for the purpose of obtaining the government subsidy.

Upon the completion of the Union Pacific Ry. I was called upon to organize the construction company and build the Texas Pacific Ry. from New Orleans to San Diego, California. In 1870 we marshalled our forces and covered the line with engineers from Marshall, Tex., to California. We were in the same condition in this work that we were on the Union Pacific; without any railroad connection, depending upon the Red River for our supplies and materials, and of course that river went dry. Nevertheless, the engineers pushed on into the country where they had the Indians, among many other difficulties to contend with.

On the line through Arizona we had a very noted engineer, Capt. R. W. Petriken. He was a graduate of West Point and had been in the engineering corps during the war. He resigned and took service with the railroads, intending to follow railroading as a business, believing there was greater possibility in it for him than in the army, but he was killed after a long fight with a band of Mexican Indians.

In building the Texas Pacific road we went through an epidemic of cholera and one of yellow fever and were subject at every town and every county line to shotgun quarantines, and notwithstanding that most of the engineers were from the north, they all stayed on the work.

In 1873 when we were rushing to close the tracks in Texas, coming from the east and west to save our land grant, the epidemic of yellow fever was upon us and every morning those of us who were at the end of the track could see numerous corpses taken out of the working gangs and buried in the dump. It took a brave, determined man of great moral courage, who was under no obligations except that of duty, to stay and fight it out.

I remember one young engineer who was setting grade and centers for the track layers. He lived in the cars that housed the convicts that were laying the track, who, no matter how much they wanted to leave, could not; he went out on his work promptly every morning and could see in the number of convicts taken out and buried, the progress of the fever, and that it was only a question of time when it would have him in its grip. I thought it possible he might leave us, so one morning I walked out and spoke to him, asking how he and his men were feeling. He said very quietly that they had considered the situation and they proposed to stay on the job until we connected the track.

As soon as the tracks were joined, I gave all the engineers who had come from the north a leave of absence, but very few of them took advantage of it.

During the years from 1870 to 1874 the line was determined and located through to California. Work was commenced at San Diego and some 500 miles were built during that time in Texas, but the Jay Cooke failure stopped us and it was not completed through to California until 1883. To-day, three of the great railways of the country occupy the line that was intended at that time for only one. They are the Texas Pacific, the Southern Pacific and the Santa Fe. It is a singular fact that the same engineers and the same foremen who had joined the tracks at Promontory Point in 1869 met on the plains at Sierra Blanco, Texas, in 1883, and joined there the tracks that united the second continental line across the country, but under entirely different circumstances. There were no bands, no crowds, no speeches, and no champagne. It was simply the engineers and foremen of the track laying forces that shook hands at this great event and it created very little notice or comment.

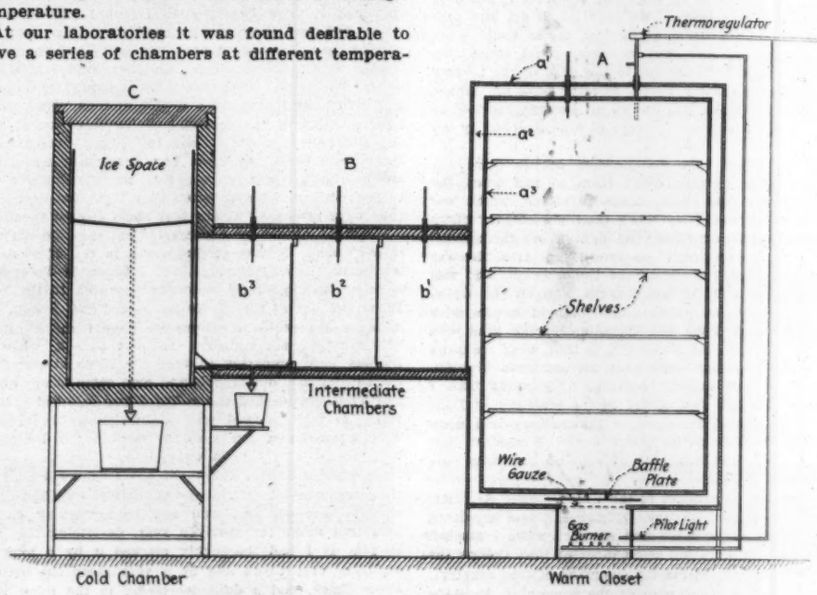
There has been a general belief throughout the country that it was a very easy problem to build a railroad. In my travels I have seen men riding in a Pullman car look out of the window and express the opinion that it was easy work or virtually no work to build a railway through the country they were passing, and make comments on what it represented and what it should cost. I often used to think as I listened to them that they should have had the experience of the builders; first as chief of a party to spy out a line, perhaps alone in an Indian country; then followed by the young engineer, carrying a rifle on one shoulder and a transit on the other, camping where his day's work ended; then the bold spirits who furnished the money to first construct the road, that would have probably to be carried 10 or 20 years before it brought any income; and then the operating department who had to reconstruct it two or three times and put millions upon millions into it to bring its commercial business and the luxury of its transportation up to our date.

An Inexpensive Thermostat for Bacteriological Specimens.

By ADDISON W. BAIRD.*

In the conduct of a laboratory where a large number of bacteriological specimens are handled, it is convenient to have a number of chambers at different temperatures. Various forms of sterilizers and other apparatus can be obtained from dealers in such wares, but most of these are relatively small in size and the larger ones are costly. In some laboratories a closet can be set aside for use as a warm room, but in such cases the whole space must be maintained at a single temperature.

At our laboratories it was found desirable to have a series of chambers at different temperatures. In the handbook, "Fermentation Organisms," by Alb. Klocker, there is described Panum's thermostat in use at the Carlsberg Laboratory, Copenhagen. Following the general plan of this apparatus we constructed a serviceable thermostat at a moderate cost, the work being done under my direction by a carpenter and a plumber.



A THERMOSTAT FOR BACTERIOLOGICAL SPECIMENS.

Division A in the accompanying illustration is the warm closet, about 6 ft. × 4 ft. × 2 ft. in size. The walls (a^1, a^2) are double, with a hot air space (a^2) 2½ ins. in width between them on all sides and at the back, and this space is lined throughout with a thin sheeting of tin. Inside the closet, the shelves rest on brackets, not touching the walls, and this aids in keeping the internal temperature everywhere the same. The front of the closet is closed by inner and outer doors having a 1-in. intermediate air space between each set. All these doors are rabbeted on their margins so as to break joints and prevent leakage of hot air. This division, A, is warmed from beneath by a V-shaped gas-heater, set with diminutive burners, each row of which is controlled by a separate turncock, and the whole controlled by a thermoregulator on top of the closet.

The pilot light has an independent gas supply and is kept constantly burning. The burners of the heater give the ordinary yellow illuminating flame, experience having shown that the blue flame (Bunsen) burners, while yielding a more intense heat, are liable to flash back and if they go out do not readily re-ignite from the pilot light. Across the opening over the heater is stretched wire netting to prevent dust and scraps from reaching the hot air space, and above the opening is placed a sheet-iron baffle plate to ensure a more equable distribution of heat. In front of the compartment containing the heater is a small glazed window, and at one side is a closely screened opening for air supply.

Division C is the cold chamber, consisting of an ordinary family refrigerator of medium size. The opening of the ice box is at the top, and permits it to be filled with broken ice, so that the temperature in the under compartment can be kept in the neighborhood of 7° C.

Siamesed in between the hot air closet and the refrigerator is Division B, which is built of outer and inner wooden walls with several layers of felt and paper between them for insulation. This intermediate section is connected at one end to the hot air space of the heated closet, a sheet-metal wall intervening, and at the other end is similarly joined to the cold box of the refrigerator. It is likewise divided into three compartments (b^1, b^2, b^3) by means of sheet-metal partitions and is fitted with shelves of the same material. The doors of this division are constructed after the manner of those of the large closet. The coldest of these compartments is metal lined and drained to carry off moisture of condensation.

Thermometers are supplied to all compartments of the apparatus and show a range of temperatures from 37½° C. to 7° C., and these temperatures are well maintained. The outside of the structure was given three coats of white paint with a final coat of glossy white. The apparatus is semi-portable, inasmuch as the three separate units, A, B and C, can be detached and moved to a new location if occasion requires. The total cost of the outfit was less than $100.

In practice the apparatus has proven satisfactory and has been of much assistance in the work of the laboratory, providing ample space for materials in use in current investigations and for stock cultures.

*30 Church St., New York City.

ACCIDENTS IN COPPER MINES in Houghton Co., Mich., have been the cause of 800 deaths in the past 23 years. During the year ended Sept. 30, 1909, 63 men were killed. This is the greatest number of casualties ever reported in one year at these mines. The nearest approach to it was in 1908 and 1905, in each of which years there were 58 fatalities. During the past year there were 17,974 men employed by the mines, stamp mills and smelters, so that the death rate per 1,000 employees was 3.50. These figures are given in an article on "Mine Accidents in Houghton Co., Mich.," by Geo. E. Edwards, in the "Mining World" of Oct. 23, 1909.

Indicating Devices for Interlocking Plants.*

The committee was instructed to investigate the various practicable methods of insuring that the interlocking unit follows the movement of its controlling lever; or, in other words, providing a substitute for the rigid connection between the lever and the unit as now used in mechanical plants. This relates to the various methods of indicating. The committee has borne in mind the interrelation of the following features of the mechanical interlocking plant: (1) The pipe line from the lever to the signal, with its mechanical bolt lock; (2) the pipe line from the lever to the facing-point lock; (3) the pipe line from the lever to the single pair of switch points.

In the early history of power interlocking, the absence of a rigid connection between the lever and the unit made necessary a device for insuring that the unit followed the movement of the lever. During the development of the art a similar precaution has been found advisable in mechanical interlocking plants. Such a device, by cutting out the possibility of human error, improved upon that old operating rule for hand throw switches which instructed the trainman or switchman to observe whether the switch point or signal blade corresponded with the position of the switch stand or signal lever, respectively. A substitute for the practice of the old rule was required as soon as the unit was removed outside of a safe visible distance from the lever.

It is considered advisable in electric plants, that in addition to the simultaneous "indication" returned at the time of the movement of a lever, there shall be provided automatically, either a prompt indication of the fact that the switch point or signal has been changed on the ground so as not to correspond with the position of its operating lever, or else some means for the instantaneous automatic return of the unit (particularly the switch or derail) to its corresponding position should there be (for any reason) an attempt to throw it out of accord with the position of its lever. This returning force has been either constantly applied to the switch or signal mechanism, or else has been, while normally cut off, instantaneously applied at the time of any opposing movement of the switch.

In electric work the method of the "indication" may be divided into four classes: (1) The direct or "battery" current; (2) the direct current with dynamic source of current at the unit operated; (3) an alternating or undulating current; (4) a comparatively high voltage "jump spark" current.

The first or direct current method for electric indication was the earliest and has been in service for about 19 years under severe operating conditions. The dynamic current with source at the unit operated was the first method extensively applied on all electric plants and has been in satisfactory service under varying severe operating conditions for a number of years.

The alternating or undulating current method of returning an indication has been designed to add to the primary purpose one of the ways to avoid annoyances due to crosses between the circuits of a plant and has many advocates. The "jump spark" method of returning an indication has been devised in addition to its primary purpose as a means of avoiding the annoyances of crosses. The scheme appeals as an ingenious method.

In each system it is now quite widely considered advisable that for each electric circuit from a lever to its unit there be provided: (1) Either some continuous means of electrically indicating any change of the unit from correspondence with its lever, or a continuous means for prevention of a "false indication"; (2) either a continuous means for electrically preventing a false movement of a unit, or a mechanical lock to prevent such a change.

In the discussion of a possible substitute for the mechanical bolt lock for use in power plants, the question at once arose of the feasibility through such a substitute of doing away with the complications of the customary forms of safety checks.

Could such a device be used as to make it impossible to clear a signal at any time until derails or diverging switches (if any) in conflicting routes are in their normal position and the switches for the required route are set and locked, it would be unessential in the operation of the plant as to the position of the units after the movement for which the clear signal was displayed has been completed through the signal limits.

Under such circumstances an efficient means of "cross protection," that is, the prevention of dangerous foreign currents in the operating or indicating circuits, could be provided, as has well been suggested by an electrical tying together of all such circuits at all times except when they are required to perform proper service. A simple means for insuring the correspondence of the unit with its lever would be an independent mechanical lock on the unit, strong enough to resist any attempt to change the unit from its normal position except in the proper way.

The committee in last year's report recommended, among other things, as specifications for electric interlocking, that circuit breakers to control high and intermediate speed signals shall be placed on all facing derail, switch and frog points, also that the circuits for facing point derails shall be controlled by normally closed circuit breakers on all signals governing over them.

These two requirements are based on the customary best practice of the day, and cover in their field the two-fold duty of a mechanical bolt lock as it is applied, except that (for example) a circuit controller for a signal on a switch does not lock the switch mechanically when the signal is clear, which is a desirable thing to accomplish. Further, it is now customary to apply to some outlying hand-throw switches a mechanical plunger lock which not only holds the independently operated switch point in place, but also controls an electric circuit to a signal, or elsewhere so that unless the switch is mechanically locked the circuit will be broken.

It would be worth while to give some individual further consideration of the application of an independent "electric bolt lock" with its mechanical lock rod and lock plunger to the necessary switches, derails and frog points in an electric interlocking plant. It is felt that possibly in such a way there might be an improvement of the service on the lines of simplicity and efficiency: (1) In simplicity, by eliminating some superseded safety checks; (2) in efficiency, by strengthening the apparatus.

*From the report of the Committee on Power Interlocking, presented at the annual meeting of the Railway Signal Association, at Louisville, Ky., Oct. 12 to 14, 1909.

Charles Melville Hays.

The election of Mr. Charles Melville Hays to succeed Sir Charles Rivers Wilson as President of the Grand Trunk Ry. Co., was announced in London Oct. 12. The retiring president is now in his 79th year, and his resignation has been expected for some time.

The promotion of Mr. Hays is rather in name than in extent of responsibility, for since his connection with the Grand Trunk in the position of Vice-President and General Manager, he has been practically its executive head. It is, however, noteworthy that the English owners of the Grand Trunk, who have hitherto insisted that the Presidency should be filled by an Englishman, have finally relinquished this idea. The absurdity of the proposition that a great railway organization could have any part of its active control and management located across an ocean from the scene of its operations long ago became evident.

Charles Melville Hays.

Charles Melville Hays was born May 16, 1856, at Rock Island, Ill. He began his railway career at the age of 17, Nov. 10, 1873, as a clerk in the passenger department of the Atlantic & Pacific R. R., at St. Louis, Mo. He was soon promoted to a clerkship in the auditor's office and later in the office of the general superintendent. In 1877 he was appointed Secretary to the General Manager of the Missouri Pacific Ry. and in 1884 he accepted a similar position with the Wabash, St. Louis & Pacific Ry. Two years later he became Assistant General Manager of the same road, and in July, 1887, he was appointed General Manager of the Wabash Western R. R., and afterward of the consolidated Wabash System. He was made Vice-President and General Manager of the Wabash R. R. in 1894, and held this position until Dec. 31, 1895. At this time he was a director of the Chicago & Western Indiana R. R., Belt Ry., of Chicago, and of other roads and was Chairman of the executive committee of the Terminal R. R. Association of St. Louis.

He became General Manager of the Grand Trunk Ry. Jan. 1, 1896, and served continuously for five years. He left the Grand Trunk Jan. 1, 1901, when he was chosen President of the Southern Pacific Co., but he retired from this position in the latter part of the same year and returned to the Grand Trunk as Second Vice-President and General Manager. His election to the presidency is effective Jan. 1, 1910. Mr. Hays is also President of the Grand Trunk Pacific Ry., Central Vermont Ry., Grand Trunk Western Ry., Grand Haven & Milwaukee Ry., Canadian Express Co., International Bridge Co. and a number of other companies affiliated with the Grand Trunk interests.

The Southern Pacific Taper Curve Tables, and Their Use with the Traverse Method.

By WM. CLYDE WILLARD.*

TRANSITION CURVES IN GENERAL.—Considering the principal transition curves as used at present, they arrange themselves into the following two classes.

Class 1. The true transition curve (approximating the cubic parabola).

Class 2. The multiform compound curve.

Curves in the first class have the following properties (with several approximations):

(a). The offsets from the tangent vary as the cubes of the lengths from the point of spiral.

(b). The deflection angles from the point of spiral vary as the squares of the distances measured along the curve.

(c). The degree of curve varies directly with the distance from the point of spiral.

Property (a) makes it possible to locate the transition by tangent offsets, and property (b) by deflection angles. Among curves which have been worked out with these properties are Talbot's Railway Transition, Crandall's Transition, Allen's Cubic Spiral, Kellogg's Transition, the curves used on the Canadian Pacific Ry., the New York Central lines, the Maine Central, etc.

The multiform compound curve, Class 2, may contain any number of chords between the limits of a one-chord terminal curve, with radius twice that of the main curve, and the cubic parabola with an infinite number of chords. Curves in Class 2 may be grouped as follows:

(a). The deflection angles are constant, while the chord length and number of chords vary.

(b). The chord length is constant, while the deflection angles and number of chords vary.

(c). The number of chords is constant, while the deflection angles and chord lengths vary.

Being compound curves, they may be located either by tangent offsets or deflection angles. Of the principal multiform compound curves in use, Searles' Railroad Spiral falls in group (a); the Southern Pacific Taper Curve, Missouri Pacific Easement Curve, Webb's Transition Curve, in group (b); and Stephens' Six-Chord Spiral, in group (c).

Most of the above curves depend for their usefulness on specially prepared tables. The following is an explanation of the Taper Curve Tables of the Southern Pacific Railroad. Similar tables are used by the Oregon Railroad & Navigation Co. and the Union Pacific Railroad.

The Southern Pacific Taper Curve.

A complete set of the Taper Curve Tables as used on the Southern Pacific Ry. is given herewith.

Seven out of nine of the taper tables give the necessary locating data for a succession of curve segments whose chord length is 30 ft., each segment having a degree (on 100-ft. chord basis) greater than the degree of the preceding segment by an amount constant for that table. Thus,

*Construction Department, Southern Pacific Railroad, San Francisco, Cal.

TABLE ½.—TAPERING CURVES CHANGING 0° 15′ EACH 30 FEET.

Transit at	DEFLECTIONS TO B.C. 0° 15′	C.C. 0° 30′	C.C. 0° 45′	C.C. 1° 00′	C.C. 1° 15′	C.C. 1° 30′	C.C. 1° 45′	C.C. 2° 00′	C.C. 2° 15′	C.C. 2° 30′	C.C. 2° 45′	C.C. 3° 00′	C.C. 3° 15′	C.C. 3° 30′	C.C. 3° 45′	C.C. 4° 00′	C.C. 4° 15′	C.C. 4° 30′	C.C. 4° 45′	C.C. 5° 00′
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
B.C. 0 15	.....	0 00½	0 00¾	0 01½	0 02¼	0 03	0 03¾	0 04½	0 05¼	0 06	0 06¾	0 07½	0 08¼	0 09	0 09¾	0 10½	0 11¼	0 12	0 12¾	0 13½
C.C. 0 30	0 00½	.....	0 01½	0 02¼	0 03	0 03¾	0 04½	0 05¼	0 06	0 06¾	0 07½	0 08¼	0 09	0 09¾	0 10½	0 11¼	0 12	0 12¾	0 13½	0 14¼
C.C. 0 45	0 01½	0 01½	.....	0 03	0 03¾	0 04½	0 05¼	0 06	0 06¾	0 07½	0 08¼	0 09	0 09¾	0 10½	0 11¼	0 12	0 12¾	0 13½	0 14¼	0 15
C.C. 1 00	0 03	0 03	0 03	.....	0 06¾	0 07½	0 08¼	0 09	0 09¾	0 10½	0 11¼	0 12	0 12¾	0 13½	0 14¼	0 15	0 15¾	0 16½	0 17¼	0 18
C.C. 1 15	0 04½	0 04½	0 04½	0 06¾	.....	0 11¼	0 12	0 12¾	0 13½	0 14¼	0 15	0 15¾	0 16½	0 17¼	0 18	0 18¾	0 19½	0 20¼	0 21	0 21¾
C.C. 1 30	0 06	0 06	0 06	0 07½	0 11¼	.....	0 15¾	0 16½	0 17¼	0 18	0 18¾	0 19½	0 20¼	0 21	0 21¾	0 22½	0 23¼	0 24	0 24¾	0 25½
C.C. 1 45	0 07½	0 07½	0 07½	0 09	0 12¾	0 15¾	.....	0 20¼	0 21	0 21¾	0 22½	0 23¼	0 24	0 24¾	0 25½	0 26¼	0 27	0 27¾	0 28½	0 29¼
C.C. 2 00	0 09	0 09	0 09	0 10½	0 14¼	0 17¼	0 20¼	.....	0 24¾	0 25½	0 26¼	0 27	0 27¾	0 28½	0 29¼	0 30	0 30¾	0 31½	0 32¼	0 33
C.C. 2 15	0 10½	0 10½	0 10½	0 12	0 15¾	0 18¾	0 21¾	0 24¾	.....	0 29¼	0 30	0 30¾	0 31½	0 32¼	0 33	0 33¾	0 34½	0 35¼	0 36	0 36¾
C.C. 2 30	0 12	0 12	0 12	0 13½	0 17¼	0 20¼	0 23¼	0 26¼	0 29¼	.....	0 33¾	0 34½	0 35¼	0 36	0 36¾	0 37½	0 38¼	0 39	0 39¾	0 40½
C.C. 2 45	0 13½	0 13½	0 13½	0 15	0 18¾	0 21¾	0 24¾	0 27¾	0 30¾	0 33¾	.....	0 38¼	0 39	0 39¾	0 40½	0 41¼	0 42	0 42¾	0 43½	0 44¼
C.C. 3 00	0 15	0 15	0 15	0 16½	0 20¼	0 23¼	0 26¼	0 29¼	0 32¼	0 35¼	0 38¼	.....	0 42¾	0 43½	0 44¼	0 45	0 45¾	0 46½	0 47¼	0 48
C.C. 3 15	0 16½	0 16½	0 16½	0 18	0 21¾	0 24¾	0 27¾	0 30¾	0 33¾	0 36¾	0 39¾	0 43½	.....	0 47¼	0 48	0 48¾	0 49½	0 50¼	0 51	0 51¾
C.C. 3 30	0 18	0 18	0 18	0 19½	0 23¼	0 26¼	0 29¼	0 32¼	0 35¼	0 38¼	0 41¼	0 45	0 47¼	.....	0 51¾	0 52½	0 53¼	0 54	0 54¾	0 55½
C.C. 3 45	0 19½	0 19½	0 19½	0 21	0 24¾	0 27¾	0 30¾	0 33¾	0 36¾	0 39¾	0 42¾	0 46½	0 49½	0 51¾	.....	0 54¾	0 55½	0 56¼	0 57	0 57¾
C.C. 4 00	0 21	0 21	0 21	0 22½	0 26¼	0 29¼	0 32¼	0 35¼	0 38¼	0 41¼	0 44¼	0 48	0 51	0 53¼	0 54¾	.....	0 57¾	0 58½	0 59¼	1 00
C.C. 4 15	0 22½	0 22½	0 22½	0 24	0 27¾	0 30¾	0 33¾	0 36¾	0 39¾	0 42¾	0 45¾	0 49½	0 52½	0 54¾	0 56¼	0 57¾	.....	1 00	1 00¾	1 01½
C.C. 4 30	0 24	0 24	0 24	0 25½	0 29¼	0 32¼	0 35¼	0 38¼	0 41¼	0 44¼	0 47¼	0 51	0 54	0 56¼	0 57¾	0 59¼	1 00	.....	1 02¼	1 03
C.C. 4 45	0 25½	0 25½	0 25½	0 27	0 30¾	0 33¾	0 36¾	0 39¾	0 42¾	0 45¾	0 48¾	0 52½	0 55½	0 57¾	0 59¼	1 00¾	1 02¼	1 03¾	.....	1 04½
C.C. 5 00	0 27	0 27	0 27	0 28½	0 32¼	0 35¼	0 38¼	0 41¼	0 44¼	0 47¼	0 50¼	0 54	0 57	0 59¼	1 00¾	1 02¼	1 03¾	1 05¼	1 06	.....

Degree of Main Curve.	"D."	"t."	Total Correction in Tapering Curve at Each End of Main Curve.	"d" = "D" less Radius of Main Curve.	Long Chord from B. C. of Taper to C. C. of Main Curve.
° ′			° ′		
0 30	11459.18	15.00	0 04½	0.01	30.00
0 45	7639.45	30.00	0 13½	0.04	60.00
1 00	5729.70	45.00	0 27	0.10	90.00
1 15	4583.96	60.00	0 45	0.20	120.00
1 30	3819.95	75.00	1 07½	0.34	150.00
1 45	3274.24	90.00	1 34½	0.55	179.99
2 00	2865.84	104.99	2 06	0.83	209.98
2 15	2547.70	119.99	2 42	1.18	239.98
2 30	2292.86	134.98	3 22½	1.62	269.96
3 00	1910.57	164.97	4 57½	2.16	329.93
3 30	1637.69	194.95	5 51	2.87	389.89
4 00	1433.55	224.77	7 00	3.67	449.51
4 30	1274.31	254.59	8 09	4.60	509.18
5 00	1147.46	284.31	9 18	5.63	568.45

RADII FOR 50 FEET CHORDS. Degree.	Radius.	Degree.	Radius.
° ′		° ′	
0 15	22918.32	5 15	1091.43
0 30	11459.17	5 30	1041.84
0 45	7639.45	5 45	996.35
1 00	5729.61	6 00	955.04
1 15	4583.69	6 15	916.83
1 30	3819.74	6 30	881.58
1 45	3274.06	6 45	848.93
2 00	2864.84	7 00	818.64
2 15	2546.52	7 15	790.45
2 30	2291.88	7 30	764.08
2 45	2083.53	7 45	739.44
3 00	1909.91	8 00	716.31
3 15	1762.91	8 15	694.62
3 30	1637.09	8 30	674.22
3 45	1527.98	8 45	654.97
4 00	1432.47	9 00	636.78
4 15	1348.21	9 15	619.58
4 30	1273.32	9 30	603.29
4 45	1206.81	9 45	587.83
5 00	1146.01	10 00	573.14

TABLE 1.—TAPERING CURVES CHANGING 0° 30′ EACH 30 FEET.

Transit at	DEFLECTIONS TO B.C. 0° 30′	C.C. 1° 00′	C.C. 1° 30′	C.C. 2° 00′	C.C. 2° 30′	C.C. 3° 00′	C.C. 3° 30′	C.C. 4° 00′	C.C. 4° 30′	C.C. 5° 00′	C.C. 5° 30′	C.C. 6° 00′	C.C. 6° 30′	C.C. 7° 00′	C.C. 7° 30′	C.C. 8° 00′	C.C. 8° 30′	C.C. 9° 00′	C.C. 9° 30′	C.C. 10° 00′
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
B.C. 0 30	.....	0 04½	0 11¼	0 21	0 33¾	0 49½	1 09¾	1 34½	2 03½	2 36¾	3 14¼	3 55½	4 40¼	5 28¾	6 21	7 16½	8 15¾	9 18¾	10 25½	11 36
C.C. 1 00	0 04½	.....	0 06¾	0 16½	0 29¼	0 45	1 04½	1 29¼	1 58¼	2 31½	3 09¼	3 50½	4 35¼	5 23¾	6 16½	7 11¾	8 11¼	9 14¼	10 21	11 31½
C.C. 1 30	0 11¼	0 06¾	.....	0 09¾	0 22½	0 38¼	0 57¾	1 22½	1 51½	2 24¾	3 02½	3 43¾	4 28½	5 17	6 09¾	7 05¼	8 04¾	9 07¾	10 14½	11 25
C.C. 2 00	0 21	0 16½	0 09¾	.....	0 12¾	0 28½	0 48	1 12¾	1 41¾	2 15	2 53	3 34¼	4 19	5 07½	6 00¼	6 55¾	7 55¼	8 58¼	10 05	11 15½
C.C. 2 30	0 33¾	0 29¼	0 22½	0 12¾	.....	0 15¾	0 35¼	1 00	1 29	2 02¼	2 40	3 21¼	4 06	4 54¼	5 47	6 42½	7 42	8 45	9 51¾	11 02¼
C.C. 3 00	0 49½	0 45	0 38¼	0 28½	0 15¾	.....	0 19½	0 44¼	1 13¼	1 46½	2 24¼	3 05½	3 50¼	4 38¾	5 31½	6 26¾	7 26¼	8 29¼	9 36	10 46½
C.C. 3 30	1 09¾	1 05¼	0 57¾	0 48	0 35¼	0 19½	.....	0 24¾	0 53¾	1 27	2 04¾	2 46	3 30¾	4 19¼	5 12	6 07¼	7 06¾	8 09¾	9 16½	10 26¾
C.C. 4 00	1 34½	1 29¼	1 22½	1 12¾	1 00	0 44¼	0 24¾	.....	0 29	1 02¼	1 39¼	2 20½	3 05¼	3 53¾	4 46½	5 41¾	6 41¼	7 44¼	8 51	10 01½
C.C. 4 30	2 03½	1 58¼	1 51½	1 41¾	1 29¼	1 13¼	0 53¾	0 29	.....	0 33¼	1 10¼	1 51½	2 36¼	3 24¾	4 17½	5 12¾	6 12¼	7 15¼	8 22	9 32½
C.C. 5 00	2 36¾	2 31½	2 24¾	2 15	2 02¾	1 46¾	1 27¼	1 02¼	0 33¼	.....	0 37	1 17¾	2 02½	2 51	3 43¾	4 38¾	5 38¼	6 41¼	7 48	8 58½
C.C. 5 30	3 09¾	3 04½	2 57¾	2 48	2 35¼	2 19¼	1 59¾	1 34¾	1 06	0 33¾	.....	0 40¼	1 25¼	2 13¾	3 06½	4 01¾	5 01¼	6 04¼	7 11	8 21½
C.C. 6 00	3 43½	3 38¼	3 31½	3 21¾	3 09¼	2 53¼	2 33¾	2 08¾	1 40	1 06¾	0 33¼	.....	0 44¾	1 33¼	2 26	3 21¼	4 20¾	5 23¾	6 30½	7 40¾
C.C. 6 30	4 16¾	4 11½	4 04¾	3 55	3 42½	3 26½	3 07	2 42	2 13¼	1 40	1 06¾	0 33¼	.....	0 48½	1 36¾	2 29½	3 28¼	4 31¼	5 38	6 48¼
C.C. 7 00	4 49½	4 44¼	4 37½	4 27¾	4 15¼	3 59¼	3 39¾	3 14¾	2 46	2 12¾	1 40	1 06¾	0 33¼	.....	0 48	1 36¼	2 29	3 31¾	4 38½	5 48¾
C.C. 7 30	5 22¾	5 17½	5 10¾	5 01	4 48½	4 32½	4 13	3 48	3 19¼	2 46	2 12¾	1 40	1 06¾	0 33¼	.....	0 47¾	1 35½	2 38¼	3 45	4 55¼
C.C. 8 00	5 56	5 50¾	5 44	5 34¼	5 21¾	5 05¾	4 46¼	4 21¼	3 52½	3 19¼	2 46	2 12¾	1 40	1 06¾	0 33¼	.....	0 48	1 51	2 58	4 08¼
C.C. 8 30	6 29¼	6 24	6 17¼	6 07½	5 55	5 39	5 19½	4 54½	4 25¾	3 52½	3 19¼	2 46	2 12¾	1 40	1 06¾	0 33¼	.....	1 03	2 10	3 20½
C.C. 9 00	7 02½	6 57¼	6 50½	6 40¾	6 28¼	6 12¼	5 52¾	5 27¾	4 59	4 25¾	3 52½	3 19¼	2 46	2 12¾	1 40	1 06¾	0 33¼	.....	1 07	2 17½
C.C. 9 30	7 35¾	7 30½	7 23¾	7 14	7 01½	6 45½	6 26	6 01	5 32¼	4 59	4 25¾	3 52½	3 19¼	2 46	2 12¾	1 40	1 06¾	0 33¼	.....	1 10¾
C.C. 10 00	8 09	8 03¾	7 57	7 47¼	7 34¾	7 18¾	6 59¼	6 34¼	6 05½	5 32¼	4 59	4 25¾	3 52½	3 19¼	2 46	2 12¾	1 40	1 06¾	0 33¼	.....

Degree of Main Curve.	"D."	"t."	Total Correction in Tapering Curve at Each End of Main Curve.	"d" = "D" less Radius of Main Curve.	Long Chord from B. C. of Taper to C. C. of Main Curve.
° ′			° ′		
1 00	5729.61	15.01	0 09	0.00	30.00
1 30	3819.80	30.00	0 27	0.06	60.00
2 00	2865.01	45.00	0 54	0.17	90.00
2 30	2292.34	60.00	1 30	0.37	120.00
3 00	1910.57	75.00	2 15	0.66	149.99
3 30	1638.17	89.99	3 09	1.08	179.98
4 00	1434.10	104.98	4 12	1.63	209.95
4 30	1275.66	119.96	5 24	2.34	239.91
5 00	1149.22	134.92	6 45	3.22	269.84
5 30	1046.14	149.87	8 15	4.30	299.73
6 00	960.63	164.79	9 54	5.59	329.57
6 30	888.71	179.69	11 42	7.11	359.35
7 00	827.58	194.54	13 39	8.89	389.03
7 30	775.02	209.35	15 45	10.94	418.61
8 00	729.62	224.10	18 00	13.28	448.05
8 30	690.14	238.78	20 24	15.92	477.32
9 00	655.66	253.38	22 57	18.88	506.41
9 30	625.47	267.88	25 39	22.18	535.25
10 00	598.97	282.27	28 30	25.83	563.82

TABLE 1½.—TAPERING CURVES CHANGING 0° 45′ EACH 30 FEET.

Transit at	Deflections to B.C. 0° 45′	C.C. 1° 30′	C.C. 2° 15′	C.C. 3° 00′	C.C. 3° 45′	C.C. 4° 30′	C.C. 5° 15′	C.C. 6° 00′	C.C. 6° 45′	C.C. 7° 30′
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
B.C. 0 45	.....	0 06¾	0 17	0 31½	0 50¾	1 14¼	1 42½	2 15	2 52	3 33¾
C.C. 1 30	0 06¾	.....	0 13½	0 30¾	0 51¾	1 17¾	1 48	2 23	3 02¼	3 45
C.C. 2 15	0 23½	0 13½	.....	0 20¼	0 43¾	1 12	1 44½	2 21¾	3 03½	3 49½
C.C. 3 00	0 49½	0 37	0 20¼	.....	0 27	0 57½	1 32¾	2 11¾	2 55½	3 43¾
C.C. 3 45	1 24½	1 06¾	0 50¾	0 27	.....	0 33¾	1 10¼	1 52½	2 35¼	3 24¾
C.C. 4 30	2 08¼	1 51½	1 30	1 04	0 33¾	.....	0 40½	1 24½	2 12¾	3 05¼
C.C. 5 15	3 01	2 42	2 18½	1 57¾	1 17¾	0 40½	.....	0 47¼	1 37¾	2 33
C.C. 6 00	4 03	3 41¾	3 15¾	2 45½	2 10¾	1 31	0 47¼	.....	0 54	1 51½
C.C. 6 45	5 14	4 50¼	4 22	3 49½	3 12¾	2 30¾	1 44¾	0 54	.....	1 00¾
C.C. 7 30	5 33¾	6 08	5 37½	5 02¾	4 23¼	3 39½	2 51	1 58	1 00¾	.....

Degree of Main Curve.	"D"	"t"	Total Ang. in Taper.	"d" = "D" less Radius of Main Curve.	Long Chord from B.C. of Taper to C.C. of Main Curve.
° ′			° ′		
1 30	3819.80	15.00	0 13½	0.06	30.00
2 15	2546.64	30.00	0 40½	0.12	60.00
3 00	1910.21	45.00	1 21	0.30	90.00
3 45	1528.56	60.00	2 15	0.60	120.00
4 30	1274.34	75.00	3 22½	1.02	149.99
5 15	1093.19	89.97	4 43½	1.65	179.94
6 00	957.50	104.95	6 18	2.46	209.89
6 45	852.47	119.87	8 06	3.52	239.74
7 30	768.95	134.82	10 07½	4.87	269.60

TABLE 2.—TAPERING CURVES CHANGING 1° 00′ EACH 30 FEET.

Transit at	DEFLECTIONS TO B.C. 1°	C.C. 2°	C.C. 3°	C.C. 4°	C.C. 5°	C.C. 6°	C.C. 7°	C.C. 8°	C.C. 9°	C.C. 10°
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
B.C. 1°	.....	0 9	0 22½	0 42	1 07¼	1 38	2 14½	3 00	3 49½	4 45
C.C. 2°	0 09	.....	0 13½	0 33	0 58	1 28¾	2 05¼	2 51¾	3 41¼	4 36¾
C.C. 3°	0 22½	0 13½	.....	0 19½	0 44¾	1 15¼	1 51¾	2 38¼	3 27¾	4 23¼
C.C. 4°	0 42	0 33	0 19½	.....	0 25¼	0 55¾	1 32¼	2 18¾	3 08¼	4 03¾
C.C. 5°	1 07½	0 58	0 44¾	0 25¼	.....	0 30½	1 07	1 53¼	2 43¾	3 39¼
C.C. 6°	1 38	1 28¾	1 15¼	0 55¾	0 30½	.....	0 36½	1 22¾	2 13¼	3 08¾
C.C. 7°	2 14½	2 05¼	1 51¾	1 32¼	1 07	0 36½	.....	0 46¼	1 36¾	2 32½
C.C. 8°	3 00	2 51¾	2 38¼	2 18¾	1 53¼	1 22¾	0 46¼	.....	0 50½	1 46¼
C.C. 9°	3 49½	3 41¼	3 27¾	3 08¼	2 43¾	2 13¼	1 36¾	0 50½	.....	0 55¾
C.C. 10°	4 45	4 36¾	4 23¼	4 03¾	3 39¼	3 08¾	2 32½	1 46¼	0 55¾	.....

Degree of Main Curve.	"D."	"t."	Total Correction in Tapering Curve at Each End of Main Curve.	"d" = "D" less Radius of Main Curve.	Long Chord from B. C. of Taper to C. C. of Main Curve.
° ′			° ′		
2°	2864.87	15.00	0 18	0.03	30.00
3°	1910.06	30.00	0 54	0.09	60.00
4°	1432.55	45.00	1 48	0.28	90.00
5°	1146.75	60.00	3 00	0.77	119.99
6°	956.40	74.99	4 30	1.36	149.98
7°	820.82	89.96	6 18	2.18	179.91
8°	719.62	104.90	8 24	3.29	209.81
9°	641.47	119.80	10 48	4.69	239.63
10°	579.88	134.66	13 30	6.45	269.35

TABLE 3.—TAPERING CURVES CHANGING 2° 30′ EACH 30 FEET.

Transit at	DEFLECTIONS TO B.C. 2° 30′	C.C. 3° 00′	C.C. 3° 30′	C.C. 4° 00′	C.C. 4° 30′	C.C. 5° 00′	C.C. 5° 30′	C.C. 6° 00′
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
B.C. 2 30	.....	0 22½	0 54¾	1 45	2 53¾	4 07½	5 41	7 29¾
C.C. 3 00	0 22½	.....	0 45	1 41½	2 52¾	4 12¾	5 56	7 56
C.C. 3 30	0 54¾	0 45	.....	1 07½	2 22¾	4 00	5 48¾	7 52½
C.C. 4 00	1 45	1 41½	1 07½	.....	1 30	3 11½	5 07¾	7 18¾
C.C. 4 30	2 53¾	2 52¾	2 22¾	1 30	.....	1 52½	3 54¾	6 15
C.C. 5 00	4 07½	4 12¾	4 00	3 11½	1 52½	.....	2 15	4 41½
C.C. 5 30	5 41	5 56	5 48¾	5 07¾	3 54¾	2 15	.....	2 37½
C.C. 6 00	7 29¾	7 56	7 52½	7 18¾	6 15	4 41½	2 37½	.....

Degree of Main Curve.	"D."	"t."	Total Correction in Tapering Curve at Each End of Main Curve.	"d" = "D" less Radius of Main Curve.	Long Chord from B. C. of Taper to C. C. of Main Curve.
° ′			° ′		
5 00	1146.11	15.00	0 45	0.10	30.00
7 30	764.48	29.99	2 15	0.40	60.00
10 00	574.12	44.97	4 30	0.99	89.98
12 30	460.56	59.93	7 30	1.97	119.92
15 00	383.68	74.86	11 15	3.43	149.76
17 30	328.20	89.62	15 45	5.48	179.43
20 00	286.04	104.27	21 00	8.20	208.80

TABLE 2½.—TAPERING CURVES CHANGING 1° 30′ TO EACH 30 FEET.

Transit at	Deflections to B.C. 1° 30′	C.C. 3° 00′	C.C. 4° 30′	C.C. 6° 00′	C.C. 7° 30′	C.C. 9° 00′	C.C. 10° 30′	C.C. 12° 00′
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
B.C. 1 30	.....	0 13½	0 33¾	1 03	1 41¼	2 28½	3 24¾	4 30
C.C. 3 00	0 13½	.....	0 27	1 00¾	1 42½	2 35¼	3 36	4 45¾
C.C. 4 30	0 47¼	0 27	.....	0 40½	1 27¾	2 24	3 29¼	4 49½
C.C. 6 00	1 39	1 14¼	0 40½	.....	0 54	1 54¾	3 04½	4 23¾
C.C. 7 30	2 48¾	2 19½	1 41¼	0 54	.....	1 07½	2 21¾	3 45
C.C. 9 00	4 16½	3 49¾	3 00	2 08¼	1 21	.....	1 34½	2 48¾
C.C. 10 30	6 02¼	5 24	4 30¾	3 40½	2 35¼	1 21	.....	1 34½
C.C. 12 00	8 06	7 23¼	6 31½	5 30¾	4 21	3 02¼	1 34½	.....

Degree of Main Curve.	"D"	"t"	Total Curvature in Tapering Curve at Each End of Main Curve.	"d" = "D" less Radius of Main Curve.	Long Chord from B.C. of Taper to C.C. of Main Curve.
° ′			° ′		
3 00	1909.97	15.00	0 27	0.06	30.00
4 30	1273.56	30.00	1 21	0.24	60.00
6 00	955.63	44.99	2 42	0.59	89.99
7 30	765.26	59.97	4 30	1.18	119.97
9 00	638.84	74.94	6 45	2.06	149.91
10 30	549.16	89.86	9 27	3.29	179.79
12 00	482.62	104.74	12 36	4.94	209.57

TABLE 2¾.—TAPERING CURVES CHANGING 2° 00′ TO EACH 30 FEET.

Transit at	Deflections to B.C. 2°	C.C. 4°	C.C. 6°	C.C. 8°	C.C. 10°	C.C. 12°	C.C. 14°
	° ′	° ′	° ′	° ′	° ′	° ′	° ′
B.C. 2 00	.....	0 18	0 45	1 24	2 15	3 18	4 33
C.C. 4 00	0 18	.....	0 36	1 21	2 18	3 27	4 48
C.C. 6 00	1 03	0 36	.....	0 54	1 57	3 12	4 39
C.C. 8 00	2 12	1 39	0 54	.....	1 12	2 38	4 06
C.C. 10 00	3 45	3 06	2 15	1 12	.....	1 30	3 09
C.C. 12 00	5 42	4 57	4 00	2 51	1 30	.....	1 48
C.C. 14 00	8 03	7 12	6 09	4 54	3 27	1 48	.....

Degree of Main Curve.	"D"	"t"	Total Curvature in Tapering Curve at Each End of Main Curve.	"d"	Long Chord.
° ′			° ′		
4 00	1432.55	15.00	0 36	0.08	30.00
6 00	955.35	30.00	1 48	0.31	60.00
8 00	717.13	44.98	3 36	0.79	89.99
10 00	574.71	59.95	6 00	1.57	119.95
12 00	480.42	74.89	9 00	2.74	149.85
14 00	413.90	89.76	12 36	4.39	179.63

TABLE 2½.—TAPERING CURVES CHANGING 2° 00′ to EACH 15 FEET.

Transit at	Deflections to B.C. 2° 00′	C.C. 4° 00′	C.C. 6° 00′	C.C. 8° 00′	C.C. 10° 00′	C.C. 12° 00′	C.C. 14° 00′	C.C. 16° 00′
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
B.C. 2 00	.....	0 09	0 22½	0 42	1 07½	1 39	2 16½	3 00
C.C. 4 00	0 09	.....	0 18	0 40½	1 09	1 43½	2 24	3 10½
C.C. 6 00	0 31½	0 18	.....	0 27	0 58½	1 36	2 19½	3 09
C.C. 8 00	1 06	0 49½	0 27	.....	0 36	1 16½	2 03	2 55½
C.C. 10 00	1 52½	1 33	1 07½	0 36	.....	0 45	1 34½	2 30
C.C. 12 00	2 51	2 28½	2 00	1 25½	0 45	.....	0 54	1 52½
C.C. 14 00	4 01½	3 36	3 04½	2 27	1 43½	0 54	.....	1 03
C.C. 16 00	5 24	4 55½	4 21	3 40½	2 54	2 01½	1 03	.....

Degree of Main Curve.	"D"	"t"	Total Curvature in Tapering Curve at Each End of Main Curve.	"d" = "D" less Radius of Main Curve.	Long Chord from B.C. of Taper to C.C. of Main Curve.
° ′			° ′		
4 00	1432.48	7.5	0 18	0.01	15.00
6 00	955.11	15.00	0 54	0.07	30.00
8 00	716.51	22.5	1 48	0.17	45.00
10 00	573.52	30.0	3 00	0.38	60.00
12 00	478.36	37.49	4 30	0.68	74.98
14 00	410.60	44.98	6 18	1.09	89.95
16 00	360.03	52.45	8 24	1.64	104.90

TABLE 4.—TAPERING CURVES CHANGING 2° 30′ EACH 15 FEET.

Transit at	Deflections to B.C. 2° 30′	C.C. 5° 00′	C.C. 7° 30′	C.C. 10° 00′	C.C. 12° 30′	C.C. 15° 00′	C.C. 17° 30′	C.C. 20° 00′
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
B.C. 2 30	.....	0 11½	0 25½	0 52½	1 21½	2 03½	2 50½	3 45
C.C. 5 00	0 11½	.....	0 22½	0 50½	1 26½	2 07½	2 59	3 58½
C.C. 7 30	0 36½	0 22½	.....	0 32½	1 13½	2 00	2 54½	3 56½
C.C. 10 00	1 22½	1 01½	0 32½	.....	0 45	1 33½	2 27½	3 30½
C.C. 12 30	2 20½	1 56½	1 24½	0 45	.....	0 56½	1 56½	3 07½
C.C. 15 00	3 32½	3 05½	2 30	1 46½	0 56½	.....	1 07½	2 26½
C.C. 17 30	5 01½	4 30½	3 59½	3 02½	2 09½	1 07½	.....	1 18½
C.C. 20 00	6 43½	6 09½	5 26½	4 33½	3 37½	2 31½	1 18½	.....

Degree of Main Curve.	"D."	"t."	Total Curvature in Tapering Curve at Each End of Main Curve.	"d" = "D" less Radius of Main Curve.	Long Chord from B. C. of Taper to C. C. of Main Curve.
° ′			° ′		
5 00	1146.03	7.50	0 22½	0.02	15.00
7 30	764.18	15.00	1 07½	0.10	30.00
10 00	573.38	22.50	2 15	0.24	45.00
12 30	459.08	29.99	3 45	0.49	59.99
15 00	383.10	37.47	5 37½	0.86	74.97
17 30	329.09	44.94	7 52½	1.37	89.93
20 00	288.90	52.39	10 30	2.06	104.85

TAPER CURVES—LATITUDE AND DEPARTURE FROM B.C.'s TO C.C.'s.

Taper ½.
Changing 0° 15′ each 30 ft.

Station.	Latitude.	Departure.
B.C. 0° 15′	0.00	0.00
C.C. 0° 30′	30.00	0.02
C.C. 0° 45′	60.00	0.10
C.C. 1° 00′	90.00	0.27
C.C. 1° 15′	120.00	0.59
C.C. 1° 30′	149.99	1.08
C.C. 1° 45′	179.99	1.79
C.C. 2° 00′	209.97	2.75
C.C. 2° 15′	239.94	4.00
C.C. 2° 30′	269.90	5.59
C.C. 2° 45′	299.84	7.56
C.C. 3° 00′	329.74	9.93
C.C. 3° 15′	359.61	12.75
C.C. 3° 30′	389.43	16.06
C.C. 3° 45′	419.18	19.90
C.C. 4° 00′	448.86	24.30
C.C. 4° 15′	478.44	29.31
C.C. 4° 30′	507.90	34.95
C.C. 4° 45′	537.23	41.26
C.C. 5° 00′	566.39	48.29

Taper 1.
Changing 0° 30′ each 30 ft.

Station.	Latitude.	Departure.
B.C. 0° 30′	0.00	0.00
C.C. 1° 00′	30.00	0.04
C.C. 1° 30′	60.00	0.20
C.C. 2° 00′	90.00	0.55
C.C. 2° 30′	119.99	1.18
C.C. 3° 00′	149.97	2.16
C.C. 3° 30′	179.94	3.57
C.C. 4° 00′	209.88	5.50
C.C. 4° 30′	239.77	8.01
C.C. 5° 00′	269.61	11.18
C.C. 5° 30′	299.35	15.10
C.C. 6° 00′	328.97	19.83
C.C. 6° 30′	358.44	25.45
C.C. 7° 00′	387.71	32.03
C.C. 7° 30′	416.73	39.65
C.C. 8° 00′	445.44	48.35
C.C. 8° 30′	473.77	58.22
C.C. 9° 00′	501.65	69.30
C.C. 9° 30′	528.99	81.65
C.C. 10° 00′	555.70	95.30

Taper 1½.
Changing 0° 45′ each 30 ft.

Station.	Latitude.	Departure.
B.C. 0° 45′	0.00	0.00
C.C. 1° 30′	30.00	0.06
C.C. 2° 15′	59.99	0.30
C.C. 3° 00′	89.99	0.82
C.C. 3° 45′	119.99	1.77
C.C. 4° 30′	149.96	3.24
C.C. 5° 15′	179.86	5.36
C.C. 6° 00′	209.73	8.24
C.C. 6° 45′	239.44	12.00
C.C. 7° 30′	269.08	16.75

Taper 2.
Changing 1° 00′ each 30 ft.

Station.	Latitude.	Departure.
B.C. 1° 00′	0.00	0.00
C.C. 2° 00′	30.00	0.03
C.C. 3° 00′	60.00	0.39
C.C. 4° 00′	89.99	1.10
C.C. 5° 00′	119.96	2.36
C.C. 6° 00′	149.90	4.32
C.C. 7° 00′	179.77	7.14
C.C. 8° 00′	209.52	10.98
C.C. 9° 00′	239.10	15.98
C.C. 10° 00′	268.43	22.30

Taper 2½.
Changing 1° 30′ each 30 ft.

Station.	Latitude.	Departure.
B.C. 1° 30′	0.00	0.00
C.C. 3° 00′	30.00	0.12
C.C. 4° 30′	59.99	0.59
C.C. 6° 00′	89.97	1.65
C.C. 7° 30′	119.93	3.53
C.C. 9° 00′	149.76	6.47
C.C. 10° 30′	179.47	10.70
C.C. 12° 00′	208.92	16.44

Taper 2¾.
Changing 2° 00′ each 30 ft.

Station.	Latitude.	Departure.
B.C. 2° 00′	0.00	0.00
C.C. 4° 00′	30.00	0.16
C.C. 6° 00′	59.99	0.78
C.C. 8° 00′	89.96	2.20
C.C. 10° 00′	119.86	4.71
C.C. 12° 00′	149.60	8.63
C.C. 14° 00′	179.06	14.23

Taper 3.
Changing 2° 30′ each 30 ft.

Station.	Latitude.	Departure.
B.C. 2° 30′	0.00	0.00
C.C. 5° 00′	30.00	0.20
C.C. 7° 30′	59.99	0.98
C.C. 10° 00′	89.94	2.75
C.C. 12° 30′	119.77	5.88
C.C. 15° 00′	149.37	10.77
C.C. 17° 30′	178.54	17.77
C.C. 20° 00′	207.01	27.23

Taper 2⅞.
Changing 2° 00′ each 15 ft.

Station.	Latitude.	Departure.
B.C. 2° 00′	0.00	0.00
C.C. 4° 00′	15.00	0.04
C.C. 6° 00′	30.00	0.20
C.C. 8° 00′	45.00	0.55
C.C. 10° 00′	59.99	1.18
C.C. 12° 00′	74.95	2.16
C.C. 14° 00′	89.88	3.53
C.C. 16° 00′	104.76	5.49

Taper 4.
Changing 2° 30′ each 15 ft.

Station.	Latitude.	Departure.
B.C. 2° 30′	0.00	0.00
C.C. 5° 00′	15.00	0.05
C.C. 7° 30′	30.00	0.25
C.C. 10° 00′	44.99	0.69
C.C. 12° 30′	59.97	1.47
C.C. 15° 00′	74.92	2.70
C.C. 17° 30′	89.82	4.46
C.C. 20° 00′	104.63	6.86

Table ½ describes a transition curve in which the constant increment of degree is 0° 15′ per segment; i. e., the first 30-ft. segment has a 100-ft. degree of 0° 15′ (and therefore covers a central angle of 0° 4½′ on 30 ft.), the next segment has a 100-ft. degree of 0° 30′, the next of 0° 45′, etc. To spiral a 1° curve with the Taper of Table ½, three 30-ft. segments would be inserted between tangent and main curve, giving the series: Tangent, 0° 15′ curve, 0° 30′ curve, 0° 45′ curve, 1° 00′ curve (main curve). Two tables for 15-ft. segments are also given, for better adaptation to sharp curves.

The tables given cover the following transitions:

Table ½....	Change of degree	0° 15′	per	30-ft.	segment
Table 1	" " "	0° 30′	"	"	"
Table 1½....	" " "	0° 45′	"	"	"
Table 2	" " "	1° 00′	"	"	"
Table 2½....	" " "	1° 30′	"	"	"
Table 2¾....	" " "	2° 00′	"	"	"
Table 3	" " "	2° 30′	"	"	"
Table 2⅞....	" " "	2° 00′	per	15-ft.	segment
Table 4	" " "	2° 30′	"	"	"

For most ordinary cases, Tables ½, 1 and 2 will be found sufficient.

The following data are given by the tables:

Main table:
1. Deflection angles from beginning of curve to point of compound curve or any intermediate station.
2. Deflection from P.C.C. to beginning of curve and intermediate stations.
3. Deflections in each direction along the taper with instrument at an intermediate station.

Small auxiliary table:
1. For every degree of main curve, the quantity D (see accompanying diagram, Fig. 1), which is equal to the radius of main curve plus the tangent offset d.
2. The tangent offset d.
3. The tangent distance t, which is the distance back from P.T. of plain curve to B.C., or the additional tangent distance required for the spiral.
4. The total central angle of the taper.
5. The length of the long chord from B.C. to any station on the taper.

There is given also a table of radii of main curve whose degree is measured on two 50-ft. chords instead of on one 100-ft. chord. These values are computed by the formula

$$R = \frac{25}{\sin \frac{1}{4} D},$$

where R = radius and D = degree of curve. For values of R not given, the tables for radii given in most handbooks may be used by taking half the radius of half the degree of curve. In using these values of R in the computations no correction for excess of arc is required when 50-ft. chords are used.

In another table are given the Latitude and Departure from tangent for each station along the taper. The tapers may therefore be located by rectangular as well as by polar coordinates.

EXAMPLE.—The following example is given to illustrate the use of the tables.

Given two curves 2° and 6°; $\Delta_2 = 4°$, $\Delta_6 = 12°$; to join the 2° curve to the initial tangent by taper ½, connect the two curves by taper 1 and join the 6° curve to the final tangent by taper 1½.

The topography renders it necessary to make a new setup at Sta. 0 + 90. Therefore, for the first

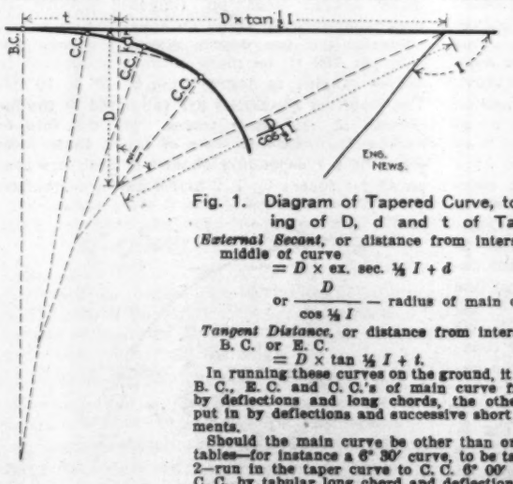


Fig. 1. Diagram of Tapered Curve, to Show Meaning of D, d and t of Tables.

(*External Secant*, or distance from intersection point to middle of curve
$= D \times$ ex. sec. $\frac{1}{2} I + d$
or $\frac{D}{\cos \frac{1}{2} I} -$ radius of main curve.

Tangent Distance, or distance from intersection point to B. C. or E. C.
$= D \times \tan \frac{1}{2} I + t$.

In running these curves on the ground, it is best to fix the B. C., E. C. and C. C.'s of main curve from each other by deflections and long chords, the other C. C.'s being put in by deflections and successive short chord measurements.

Should the main curve be other than one shown in the tables—for instance a 6° 30′ curve, to be tapered per Table 2—run in the taper curve to C. C. 6° 00′ (putting in this C. C. by tabular long chord and deflection), and then run in 15 ft. of 6° curve to C. C. 6° 30′—in all cases taking some convenient length of chord for the last compounding of the taper, which length shall have as nearly as may be the same relation to the tabular chord length as the main curve bears to the adjacent tabular curves. Get corrected values of D and t by multiplying cosine and sine of total curvature up to main curve by the difference of radii of main curve and last branch of compound curve; subtract cosine product from D, and add sine product to t, as taken from the table for the last branch of the compound curve.)

part of the spiral, transit being set at B. C., refer to Table ½ and follow from left to right across the first horizontal line to vertical column headed C. C. 1° 00′, using the deflections for C.C. 0° 30′, C. C. 0° 45′, and C. C. 1° 00′, as recorded. Shift the transit to Sta. 0 + 90, backsight on B. C., and turn off an angle found in the horizontal line marked "Transit at C. C. 1° 00′," in

Fig. 2. Taper 1 Connecting 2° and 6° Curves; Computation of Long Chord.

the first column, "B. C. 0° 15′," where is found the required deflection 0° 16½′ This gives the tangent to the compound curve at the instrument. In the same horizontal line follow horizontally to right from the blank space, setting off the successive deflections, until column C. C. 2° 00′ is reached. As the main curve is 2°, the last deflection, or deflection to P. C. C., is found in this column (0° 43¾′). Setting up on the P. C. C., and backsighting on Sta. 0 + 90, a deflection of 0° 55¼′ gives the tangent at

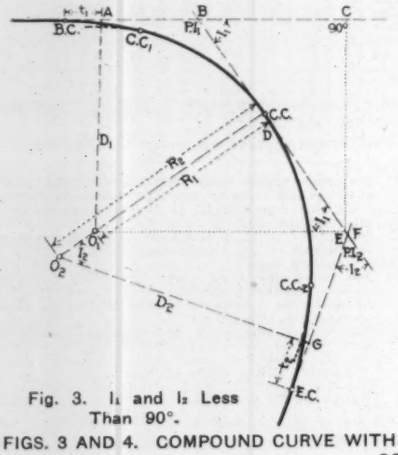


Fig. 3. I_1 and I_2 Less Than 90°.

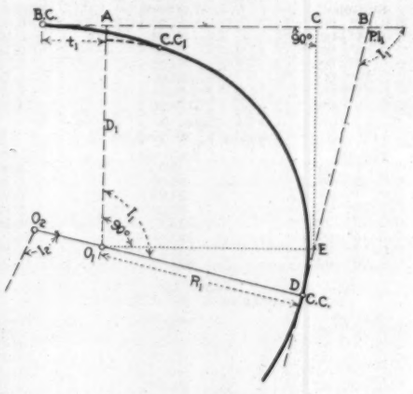


Fig. 4. I_1 and I_2 Greater Than 90°.

FIGS. 3 AND 4. COMPOUND CURVE WITH END TAPERS ONLY; FOR TANGENT DISTANCE COMPUTATION.

P. C. C.; this deflection is found in the horizontal line "Transit at C. C. 2° 00′" in column C. C. 1° 00′.

For the taper connecting the 2° and 6° curves: Referring to Table 1, it is seen that there are eleven stations in a taper for a 6° curve and three stations for a 2° curve, every 30-ft. chord of the taper differing 0° 30′ in degree of curvature from the chord on each side of it. This would give 8 segments, but, as the 2° curve must be considered as one chord-length of the taper, there will be only 7 segments in the transition between the two curves. With transit set up at the end of the 2° curve, the next segment is of degree 2° 30′, and the transit is therefore at a point corresponding to C. C. 2° 30′ of a complete taper. Therefore run down column C. C. 2° 30′ to the blank space (which is in the horizontal line C. C. 2° 30′), then follow across to the right horizontally, obtaining the forward deflections 0° 22½′, 0° 47¼′, etc., to the final one for P. C. of the 6° curve in column C. C. 6° 00′ (3° 36′). These deflections are to be laid off from the tangent to the 2° curve, found by turning off ½ $\Delta_2 = 2°$ from a backsight on the beginning of the 2° curve (Sta. 2 + 10).

To find length of long chord of the connecting taper (Sta. 4 + 10 to Sta. 6 + 20) refer to Fig. 2, where EB represents the 2° curve and CD the 6° curve. Produce the taper from B back to its origin at A. The tangents to the taper at A and C are shown by A X and C Y.

AB = 4 segments; BC = 7 segments.

From auxiliary table of Table 1, long chord AB = 120 ft.; long chord AC = 329.57 ft. In the first line of main table, "Transit at B. C.," we find in column C. C. 2° 30′, the deflection angle XAB = 0° 33¾′, and in column C. C. 6° 00′ the angle XAC = 3° 27′. Angle BAC is their difference, or 2° 53¼′. Similarly, in horizontal line "Transit at C. C. 6° 00′" we find in column B. C. 0° 30′ the deflection angle YCA = 6° 27′; in column C. C. 2° 30′ the deflection angle YCB = 4° 48′; and by subtraction we obtain angle BCA = 1° 39′. In triangle ABC,

$$BC = \frac{120 \times \sin 2° 53¼'}{\sin 1° 39'} \text{ or } BC = \frac{329.57 \times \sin 2° 53¼'}{\sin 4° 32¼'}$$

To obtain deflections for the terminal taper, which is to be No. 1½, in Table 1½ commence at blank space in column C. C. 6° 00′ and follow to the left, setting off the successive deflections. Suppose that at point Sta. 9 + 40 an intermediate setup is required. Then, having located this point by deflection (to C. C. 3° 00′), set the transit here, backsight on P. C. C. (the last position of the instrument), and get the tangent by turning off angle 2° 11¾′ found in the horizontal line "Transit at C. C. 3° 00′" in column C. C. 6° 00′. From this tangent the remaining deflections are then turned off as found in the same horizontal, to the left of the blank space, viz., 0° 20¼′, 0° 37′, and 0° 49½′ to E. C.

GRADE COMPENSATION ON TAPERS.—The Southern Pacific Ry. uses a sliding scale for compensation of grades for curvature. The grade on the taper is compensated by the rule that the maximum grade rate on a taper is the mean of the maximum grade on tangent and the maximum grade on main curve to which the taper belongs. Tables are printed for the various maximum grades used on tangents. With the maximum rate of grade on tangent and rate of compensation per degree given, the maximum rate per 100 ft. on main curve is computed for curves ranging in degree from 0° 15′ to 10° 00′. The resulting quantities are tabulated in the last column of the grade tables. By the rule for finding the maximum rate of taper, these rates, with the corresponding change in feet, are computed for tapers ½, 1, 2 and 3 and are tabulated in the left-hand side of the tables. Two of these tables, one for maximum grade of 1.4% on tangent, and one for maximum grade of 2.2% on tangent, are shown.

Formulas to be Used With S. P. Tapered Curves.

A. COMPOUND CURVE WITH TAPERS; I_1 AND I_2 EACH LESS THAN 90°. (Fig. 3.)

Tangent distance B. C. to P. I_1. is

$$AB + t_1 = O_1E - BC + t_1 = \frac{R_1}{\sin I_1} - \frac{D_1}{\tan I_1} + t_1$$

Tangent distance P. I_1. to C. C.,

$$BE - DE = \frac{D_1}{\sin I_1} - \frac{R_1}{\tan I_1}$$

By adapting the same solution to the other branch, we get

$$\text{C. C. to P. } I_2. = \frac{D_2}{\sin I_2} - \frac{R_2}{\tan I_2}$$

$$\text{P. } I_2. \text{ to E. C.} = \frac{R_2}{\sin I_2} - \frac{D'}{\tan I_2} + t_2$$

B. COMPOUND CURVE WITH TAPERS; I_1 AND I_2 EACH GREATER THAN 90°. (Fig. 4.)

Tangent distance B. C. to P. I_1.,

$$AB + t_1 = OE + BC + t_1 = \frac{R_1}{\sin I_1} + \frac{D_1}{\tan I_1} + t_1$$

Tangent distance P. I_1. to C. C.,

$$BE + DE = \frac{D_1}{\sin I_1} + \frac{R_1}{\tan I_1}$$

Tangent distance C. C. to P. I_2.,

$$\frac{D_2}{\sin I_2} + \frac{R_2}{\tan I_2}$$

Tangent distance P. I_2. to E. C.,

$$\frac{R_2}{\sin I_2} + \frac{D_2}{\tan I_2} + t_2$$

C. SIMPLE CURVE WITH UNEQUAL TAPERS; I LESS THAN 90°. (Fig. 5.)

Tangent distance B. C. to P. I. is

$$AB + t_1 = OE - BC + t_1 = \frac{D_2}{\sin I} - \frac{D_1}{\tan I} + t_1$$

Tangent distance P. I. to E. C. is

$$BD + t_2 = BE - DE + t_2 = \frac{D_1}{\sin I} - \frac{D_2}{\tan I} + t_2$$

D. SIMPLE CURVE WITH UNEQUAL TAPERS; I GREATER THAN 90° (Fig. 6.)

Tangent distance B. C. to P. I. is

$$AB + t_1 = OE + BC + t_1 = \frac{D_2}{\sin I} + \frac{D_1}{\tan I} + t_1$$

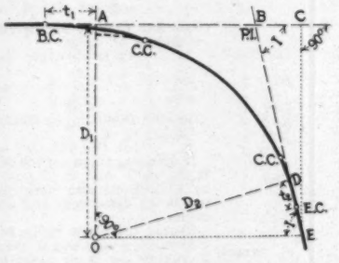


Fig. 5. I Less than 90°.

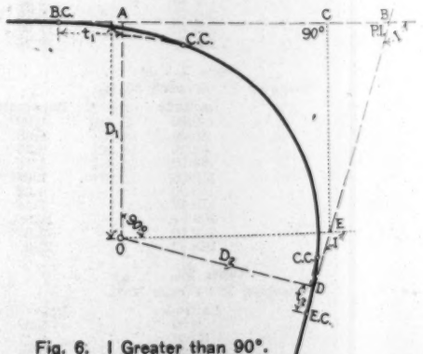


Fig. 6. I Greater than 90°.

FIGS. 5 AND 6. CURVE WITH DIFFERENT END TAPERS; FOR TANGENT DISTANCE COMPUTATION.

MAXIMUM GRADE ON TANGENT 2.2 FT. PER 100.

Main curve.	Tapers on 2.2% Maximum Grade. Rate on tapers.	Taper ½. Change in feet.	Taper 1. Change in feet.	Taper 2. Change in feet.	Taper 3. Change in feet.	Main Curve on 2.2% Maximum Grade. Main curve.	Rate per degree per 100-ft. sta.	Rate per 100 feet.
.....	.....	.....	.....	.....	.....	0° 15′	0.035	2.19125
0° 30′	2.19125	0.657	.....	.....	.....	0° 30′	.....	2.1825
0° 45′	2.186875	1.312	.....	.....	.....	0° 45′	.....	2.17375
1° 00′	2.1825	1.964	0.655	.....	.....	1° 00′	.....	2.165
1° 15′	2.178125	2.614	.....	.....	.....	1° 15′	.....	2.15625
1° 30′	2.17375	3.261	1.304	.....	.....	1° 30′	.....	2.1475
1° 45′	2.169375	3.905	.....	.....	.....	1° 45′	.....	2.13875
2° 00′	2.165	4.547	1.949	0.650	.....	2° 00′	.....	2.13
2° 15′	2.160625	5.186	.....	.....	.....	2° 15′	.....	2.12125
2° 30′	2.15625	5.822	2.588	.....	.....	2° 30′	.....	2.1125
2° 45′	2.151875	6.456	.....	.....	.....	2° 45′	.....	2.10375
3° 00′	2.1475	7.087	3.321	1.289	.....	3° 00′	0.035	2.095
3° 15′	2.135	7.686	.....	.....	.....	3° 15′	0.040	2.07
3° 30′	2.13	8.307	3.834	.....	.....	3° 30′	.....	2.06
3° 45′	2.125	8.925	.....	.....	.....	3° 45′	.....	2.05
4° 00′	2.12	9.540	4.452	1.908	.....	4° 00′	.....	2.04
4° 15′	2.115	10.152	.....	.....	.....	4° 15′	.....	2.03
4° 30′	2.11	10.761	5.064	.....	.....	4° 30′	.....	2.02
4° 45′	2.105	11.367	.....	.....	.....	4° 45′	.....	2.01
5° 00′	2.10	11.970	5.670	2.520	0.630	5° 00′	.....	2.00
5° 30′	2.09	.....	6.270	.....	.....	5° 30′	.....	1.98
6° 00′	2.08	.....	6.864	3.120	.....	6° 00′	0.040	1.96
6° 30′	2.05375	.....	7.394	.....	.....	6° 30′	0.045	1.9075
7° 00′	2.0425	.....	7.906	3.677	.....	7° 00′	.....	1.885
7° 30′	2.03125	.....	8.531	.....	1.219	7° 30′	.....	1.8625
8° 00′	2.02	.....	9.090	4.242	.....	8° 00′	.....	1.84
8° 30′	2.00875	.....	9.642	.....	.....	8° 30′	0.045	1.8175
9° 00′	1.975	.....	10.073	4.740	.....	9° 00′	0.050	1.750
9° 30′	1.9625	.....	10.598	.....	.....	9° 30′	.....	1.725
10° 00′	1.95	.....	11.115	5.265	1.755	10° 00′	0.050	1.700

The maximum grade rate on tapers is the mean of the maximum grade on tangent and the maximum grade on the main curve to which the taper curve belongs.

MAXIMUM GRADE ON TANGENT 1 4-10 FT. PER 100.

Main curve.	Tapers on 1 4-10 ft. per cent. Maximum Grade. Rate on tapers.	Taper ½. Change in feet.	Taper 1. Change in feet.	Taper 2. Change in feet.	Taper 3. Change in feet.	Main Curve on 1 4-10 ft. per cent. Maximum Grade. Main curve.	Rate per degree per 100-ft. sta.	Rate per 100 feet.
.....	.....	.....	.....	.....	.....	0° 15′	0.035	1.39125
0° 30′	1.39125	0.417	.....	.....	.....	0° 30′	.....	1.3825
0° 45′	1.386875	0.832	.....	.....	.....	0° 45′	.....	1.37375
1° 00′	1.3825	1.244	0.415	.....	.....	1° 00′	.....	1.365
1° 15′	1.378125	1.654	.....	.....	.....	1° 15′	.....	1.35625
1° 30′	1.37375	2.061	0.824	.....	.....	1° 30′	.....	1.3475
1° 45′	1.369375	2.465	.....	.....	.....	1° 45′	.....	1.33875
2° 00′	1.365	2.867	1.229	0.410	.....	2° 00′	.....	1.33
2° 15′	1.360625	3.266	.....	.....	.....	2° 15′	.....	1.32125
2° 30′	1.35625	3.662	1.628	.....	.....	2° 30′	.....	1.3125
2° 45′	1.351875	4.056	.....	.....	.....	2° 45′	.....	1.30375
3° 00′	1.3475	4.447	2.021	0.809	.....	3° 00′	0.035	1.295
3° 15′	1.335	4.806	.....	.....	.....	3° 15′	0.040	1.27
3° 30′	1.33	5.187	2.394	.....	.....	3° 30′	.....	1.26
3° 45′	1.325	5.565	.....	.....	.....	3° 45′	.....	1.25
4° 00′	1.32	5.940	2.772	1.188	.....	4° 00′	.....	1.24
4° 15′	1.315	6.312	.....	.....	.....	4° 15′	.....	1.23
4° 30′	1.31	6.681	3.144	.....	.....	4° 30′	.....	1.22
4° 45′	1.305	7.047	.....	.....	.....	4° 45′	.....	1.21
5° 00′	1.30	7.410	3.510	1.560	0.390	5° 00′	.....	1.20
5° 30′	1.29	.....	3.870	.....	.....	5° 30′	.....	1.18
6° 00′	1.28	.....	4.224	1.920	.....	6° 00′	0.040	1.16
6° 30′	1.25375	.....	4.514	.....	.....	6° 30′	0.045	1.1075
7° 00′	1.2425	.....	4.846	2.237	.....	7° 00′	.....	1.085
7° 30′	1.23125	.....	5.171	.....	0.739	7° 30′	.....	1.0625
8° 00′	1.22	.....	5.490	2.562	.....	8° 00′	.....	1.04
8° 30′	1.20875	.....	5.802	.....	.....	8° 30′	0.045	1.0175
9° 00′	1.175	.....	5.993	2.820	.....	9° 00′	0.050	0.95
9° 30′	1.1625	.....	6.278	.....	.....	9° 30′	.....	0.925
10° 00′	1.15	.....	6.555	3.105	1.035	10° 00′	0.050	0.9

The maximum grade rate on tapers is the mean of the maximum grade on tangent and the maximum grade on the main curve to which the taper curve belongs.

Tangent distance P. I. to E. C. is

$$BD + t_2 = BE + DE + t_2$$

$$= \frac{D_1}{\sin I} + \frac{D_2}{\tan I} + t_2$$

E. SPECIAL SEMI-TANGENT FORMULA for curves joining tapers whose rate of change does not correspond with tables, e. g., 8° 30′ curve and taper 2½.

Let R = radius of main curve,
α = curvature in main curve,
β = curvature in one taper,
$\Delta = \alpha + 2\beta$ = total curvature,
C = departure of taper,
and L = latitude of taper.

If $A = R \tan \frac{1}{2} \alpha \cos \beta$, and

$B = (A \tan \beta + C) \tan \frac{1}{2} \Delta$,

then $A + B + L$ = semi-tangent.

The Traverse Method Applied to Curves with S. P. Tapers.

A. COMPOUND CURVE WITH TWO TAPERS.—Given the compound curve $D_1°$ and $D_2°$, central angle Δ, length HI and number of taper table to be used. To connect curve to tangents by tapers and find Δ_1, Δ_2, position of B. C. and length of semi-tangent P. I. to E. C. (Fig. 7).

Assume bearing of GI as north and solve traverse $GIHO_1O_2$ for length GI and bearing O_1O_2. Length IH is given. The taper having been selected, read from it

$$HO_1 = D_1, \text{ and } O_2G = D_2.$$

The degrees of the two curves being given, find the radii; then

$$O_1O_2 = R_1 - R_2.$$

When bearing of GI is assumed north, the departures all become known but that of O_1O_2. It is found by taking the difference between the plus and minus departures.

$$\text{Then, } \sin(\text{bearing } O_1O_2) = \frac{\text{dep. } O_1O_2}{\text{length } O_1O_2},$$

and latitude O_1O_2 = cos (bearing O_1O_2) length O_1O_2.

The length of GI is equal to its latitude, and is found by taking the difference between all plus and minus latitudes.

The spiral leads t_1 and t_2 being found from the table, we have the semi-tangents

$$AI = t_1 + HI, \text{ and } IS = t_2 + GI.$$

These locate the position of the B. C. and E. C. Angle HO_1O_2 results from difference of bearings of HO_1 and O_1O_2. Angle PO_2G results from difference of bearings of O_1O_2 and O_2G. Angles α and β are taken from the table.

$$\therefore \Delta_1 = HO_1O_2 - \alpha, \text{ and } \Delta_2 = PO_2G - \beta.$$

The solution is the same whether the two tapers are from the same or different tables.

B. COMPOUND CURVE WITH THREE TAPERS.—Given two tangents whose angle of intersection is known. Join them by a two-centered compound curve. The degrees of curve of the simple curves (CE and FG, Fig. 8) are known. Join the curves to the tangents and to each other by taper curves. Find lengths of semi-tangents and long chord.

In Fig. 8, draw CB, ED, FK, perpendicular to the tangent AP; GH perp. to tangent JP; Cb and EL parallel to tangent AP.

Let R_1 and Δ_1 be the radius and central angle of C E; R_2, Δ_2 of FG. Also let α, β, γ be the total curvature in the tapers AB, EF, GJ. The total central angle Δ is also known.

The degrees of curve CE and FG are known. The number of the tapers to be used must now be decided upon and the central angle, or total curvature, of each taper taken from the tables. The central angle of one of the main curves may be known. If not, assume the central angle of one, and the central angle of the other $= \Delta - (\alpha + \beta + \gamma + \Delta_x)$, where Δ_x = known or assumed central angle of simple curve.

The latitude and departure of the first taper are AB and CB, as taken from the table.

$$\text{Long chord } CE = 2R \sin \tfrac{1}{2} \Delta_1,$$
$$\text{angle } bCE = \alpha + \tfrac{1}{2} \Delta_1,$$
$$Cb = CE \cos bCE,$$
$$\text{and } Eb = CE \sin bCE.$$

The length of chord EF may be found in two ways. First, by projecting the 30-ft. chords of the taper on the long chord EF by multiplying each chord length by the cosine of the deflection angle. Second, by the method explained previously in the Example of the use of the tables. The latter is more accurate and shorter.

Long chord E F having been found, if θ = deflection angle from table for locating F from tangent to curve at E,

$$\text{Angle } LEF = \alpha + \Delta_1 + \theta,$$
$$EL = EF \cos LEF,$$
$$FL = EF \sin LEF,$$
$$FK = CB + Eb + FL.$$

The latitude and departure of the final taper, JH and GH, are also taken from the table.

$$\text{Angle } HGF = 90° + \gamma + \tfrac{1}{2} \Delta_2.$$

In the traverse PHGFK the bearings of all lines are known and lengths PK and PH are unknown. Assume HP as north, making its departure zero. The departure of PK then is the difference between all the plus and minus departures, whence

$$\text{Length } PK = \frac{\text{departure } PK}{\sin(\text{Bearing } PK)}.$$

Next take out latitude of PK. The latitude of HP may now be found by subtraction, and the length of HP is equal to its latitude. The lengths of the semi-tangents are now known; angle Δ being known, the long chord AJ is found by,

$$\tan \frac{1}{2}(J - A) = \frac{AP - JP}{AP + JP} \tan \frac{1}{2}(J + A)$$

and chord $$AJ = \frac{JP \sin \Delta}{\sin A}$$

where A and J represent the interior angles at those points.

In this problem the three tapers may be taken from the same or different tables without changing the method of solution. Or Δ_1 and Δ_2 may

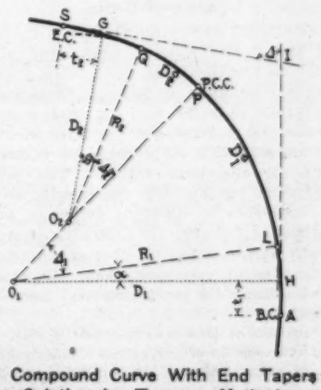


Fig. 7. Compound Curve With End Tapers Only; Solution by Traverse Method.

be given and Δ found. A similar method may be used with a three or more centered compound curve.

C. A CROSSOVER WITH TAPERS.—Given two parallel tangents whose spacing is known;

to locate between them a crossover with tapers. In Fig. 9, suppose DE represents a short tangent of known length in the crossing. The total curvature AD must equal the total curvature in EH. Fix upon the degrees of curve BC and FG and the tapers to be used; then the above condition gives a relation between the central angles Δ_1 and Δ_2 of the curves BC and FG.

Assume bearing of AK as north. The deflections for the chords AB, BC, CD, etc., are found from the tables and hence their bearings are

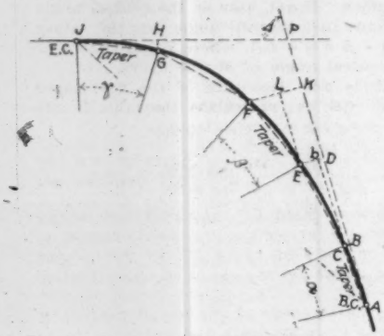


Fig. 8. Compound Curve With End and Intermediate Tapers; Traverse Solution.

known, partly in terms of Δ_1. Solve traverse ABCDEFGH for length and bearing of the closing side HA. The length times sine of bearing must equal track spacing HK, which gives a condition from which Δ_1 may be calculated, and thence Δ_2. Using these values in the expression for the bearing of AH, this bearing is determined, and

$$AK = KH \cot (\text{Bearing } AH).$$

This enables the points A and H to be located on the ground.

The solution is not changed if the short tangent DE is omitted.

American and Foreign Practice as to Rail Lengths and Rail Joints

One of the subjects for discussion at the meeting of the International Railway Congress to be held in Switzerland next year is that of rail joints, and a report concerning practice in English-speaking countries has been prepared by Mr. Alexander Ross, M. Inst. C. E., Engineer in Chief of the Great Northern Ry. (of England). This report is published in the August "Bulletin" of the Internal Railway Congress Association, and from it we take some of the information given below. It may be noted that the report is based largely upon the replies to circulars of enquiry, and that it covers the following points: (1) reducing the number of joints by increasing the length of rails; (2) maximum length of rails; (3) welding rail joints; (4) strengthening rail joints.

Length of Rails.

GREAT BRITAIN.—In Great Britain and Ireland the railways have been gradually increasing the length of the rails, with a view to reducing the number of joints. Some railways still use rails only 30 ft. long, and a few use 60-ft. rails, but a large number have 45-ft. rails and it appears that this may be taken as a standard for the near future. The principal reasons given for limiting the length, as given by the engineers of different railways, may be summarized as follows: (1) Difficulty of straightening rails at the mills; (2) cost of manufacture; (3) difficulties of transportation; (4) expansion and contraction; (5) unloading and handling on the track.

So far the use of long rails does not appear to have called for the adoption of any special arrangements other than proper proportioning of the bolt holes and the play at the joints, and the strengthening of the maintenance gangs (by consolidating neighboring gangs or otherwise) while handling long rails. The temperature varies from 0° F. in winter to a maximum of 130° F. in the sun in summer. To allow free play for expansion during extreme heat, it is the practice of most engineers to ease the joints by slackening the nuts.

As to the loads sustained, the maximum load carried by a pair of driving wheels is given as 21 tons (varying from 16 to 21 tons), but there is a tendency to increase this to 22 tons.

UNITED STATES.—The standard length on a number of railways is 33 ft., and the reasons given for limiting the length are in general similar to those noted above. Experiments have been made with rails of greater length, but on the whole these have not been satisfactory, although the opinions expressed by some of the railways give 40 ft., 45 ft., 50 ft. and 60 ft. as admissible lengths. The range of temperature

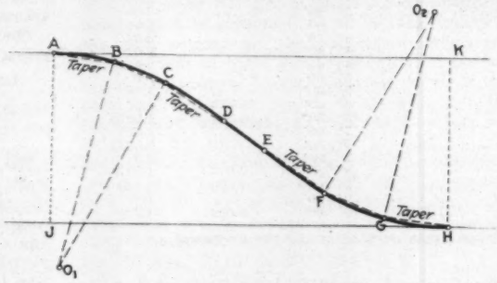


Fig. 9. Crossover with Both Curves Tapered; Traverse Solution.

is 100° F. in some parts of the country, while in others it is 180° F. In some cases, the nuts are slackened in the early part of the summer.

The maximum load on a driving axle is given as 27.6 tons, while several roads give about 25 tons.

OTHER COUNTRIES.—This is a somewhat vague class, including 17 railways in South America, India, South Africa, Australia and Canada. The limiting length of rails varies from 30 to 40 ft. The range of temperature is from 100° to 155° in India, and 160° in South Africa and Australia. The maximum loads per driving-axle are comparatively light, ranging from 12.6 to 16.75 tons, except that in Canada it is 21.75 tons.

Strengthening Rail Joints.

GREAT BRITAIN.—The suspended joint is almost universal in Great Britain and Ireland, although many railways formerly used supported joints. Practically all these railways use bull-head rails carried in chairs. A number of railways have experimented with special forms of joints, mainly in the line of a base support or bridge to support the ends of the rails between the joint chairs. In some cases this is a single casting forming the two chairs and the bridge piece, while in others a separate plate or a piece of old rail (seated in the chairs) forms the bridge. One curious arrangement which has been applied to both bull-head and tee rails on the Great Northern of Ireland Ry. has a tie laid longitudinally under each joint (the rails being laid with square joints). To maintain the gage, a tie bar is used, passing under the two longitudinal ties and having its ends bent up against their outer faces.

It is worth noting that the type of joint in which the rail ends are relieved from load by a bridge rail placed against the track rails, so as to engage the outer edge of the wheel tread as it crosses the joint, has been tried and found unsatisfactory. The relieving rail seems to be about 5 ft. long, with the head planed on an incline so that the actual wheel bearing would be only at the joint. These joints were applied to 1⅛ miles of track on the London & Northwestern Ry., but after a trial of eight years they had to be replaced by ordinary splice bars. A similar type of joint has been tried in this country, and with the same results as noted below.

In most cases plain flat splice bars are used, of short lengths and with four bolts. On the Great Northern Ry., the bars are 18 ins. long, weighing 32.3 lbs. per pair, and having the holes 4½ ins. c. to c. The ends of these bars (for a length of 2⅛ ins.) rest on seats formed in the joint chairs. The joint ties are 12 ins. wide (the ordinary ties being 10 ins. wide), and are 11½ ins. apart in the clear.

Weakness of the joint, as compared to the solid rail, is the most general reason assigned for low joints. This applies to both British and American railways.

UNITED STATES.—Mr. Ross states that "the type of joint used is almost universally the bridge joint, very few companies using supported or suspended joints." This, of course, is erroneous, for while bridge joints of various kinds are used to a large extent, the ordinary suspended joint with angle-bar splices is a standard type. The error appears to be due to regarding as standard or universal the types of joints noted by the various railways under the heading of "most recent types of joints employed" in the circular of enquiry. As to experiments on the Pennsylvania Lines, the paper quotes a report from the engineer, as follows:*

In 1895 and subsequent years a number of different kinds of joints were put in the track for experimental purposes. Experiments were discontinued as a result of an inspection in 1904. Briefly the faults noted were as follows:

1. Barschall.—Did not prevent depression of the joint. Carrying rail gave blow to worn wheels. (It is claimed that this was due largely to improper maintenance and also to the fact that the joint as used was more or less of a makeshift, the carrying rails being cut from old rails and not fitting as snugly to the main rails as they should.)

2. Churchill.—Expensive to maintain. Bolts under the rails cannot be kept tight.

3. Weber. Expensive to maintain. Bolts cannot be kept tight.

4. Continuous.—Required a large amount of labor, and in spite of this took extremely large permanent set. A large number cracked near the base.

5. Triple-Fish.—Do not hold up well. In many cases the rail breaks near the end of the base-plate supporting the rail.

6. Miter.—No better results than square ends.

Continuous Rails.

Enquiry was made as to whether any railways contemplated welding the rails at the joints. All the replies were in the negative, and the general opinion was that continuous rails would be unsafe, on account of the temperature changes. It is well known, of course, that welding the joint is common practice in street railway work, but in such cases the rails are protected by the paving so that only a small portion is exposed. This, however, is not mentioned by Mr. Ross, who is dealing only with ordinary railways. He quotes, however, the following report from the Pennsylvania Lines regarding an interesting experiment with continuous rails.

In 1897, a continuous rail 1,050 ft. long, made up of 35 80-lb., 30-ft. rails joined by angle bars with drilled holes and machine turned bolts (no provision being made for expansion and contraction), was laid in the eastbound main track, near New Brighton, Pa. The ends were held by bent rails bedded in concrete, so placed as to bear against the ties. Special long and wide angle bars were used at the ends, fastened to the anchor ties with lag screws. The track was a tangent with stone ballast.

The rail crept and kinked out of line badly. An examination made in August, 1900, after three years' service, showed that the entire rail crept in the direction of traffic (eastward). At the west anchorage, the vertical holding rails had cut into the cross-ties forming the anchorage frame work, while at the east anchorage there was a space of 1⅝ ins. between the vertical rails and the frame work. All of the spikes were bent eastward, and both slots and spikes were badly cut. The bolts were all slightly sprung. The alinement at the joints was very bad.

Conclusions.

We give the general conclusions presented by Mr. Ross substantially in full, as follows:

In Great Britain and Ireland, the lengthening of rails and the consequent reduction of the number of joints has been steadily proceeding at an increasing rate during the past 60 years.

In 1840-1850, the normal length of rolled iron rails was from 15 to 18 ft. The length of these iron rails in-

*The Barschall joint is of the relieving type, with a carrying or relieving rail bolted against the outside of the rail ends to engage the wheel treads. The Churchill joint has a base plate engaging with deep splice bars which are connected by bolts under the rails. The Weber joint has an L-shaped bridge plate independent of the two splice bars. The Continuous joint has splice bars bent to fit under the edges of the rail base and thus act as a bridge support. The Triple-fish joint has a short base plate (not resting on the ties) attached to the flanges of short angle bars by a transverse U-bolt. The Miter joint has the rail ends cut diagonally (the angle in this case is not stated).

creased at the rate of about 3 ft. in each decade until 1870-1880 when steel rails from 24 to 30 ft. long were brought into general use. Since then the decennial increase has been about 4½ ft., and at the present time rails 36 ft. and 45 ft. long are in general use, while two railways have adopted rails 60 ft. in length.

In 1904, when the Engineering Standards Committee issued the British Standard sections, it recommended the adoption of the following as the normal lengths of rails: 30, 36, 45 or 60 ft.

In other countries embraced by this report, the length of rails has been steadily and uninterruptedly increasing, but within narrower limits than in Great Britain and Ireland.

It is evident that if it were possible to have continuous rails on long stretches of railway, attained by relaying with rails as long as practicable and afterwards welding at the joints, the running would be smoother. But the natural law of expansion and contraction absolutely prevents this. The experience of engineers in observing the effects of expansion as well as the experiments made by the engineers of the Pennsylvania Lines are valuable in proving the impossibility of dispensing with joints.

The returns go also to prove that from purely practical points of view, it is not desirable to have rails of too great a length, the maximum lying somewhere between 45 and 60 ft. Even 45 ft. is considered by many as being too long for transportation. This is especially the case in the United States, where 33 ft. is generally considered as the maximum length.

The writer is of opinion that 45 ft. is sufficiently long considering the effect of expansion and contraction and the gap which is left between the rails at low temperatures.

It is that unavoidable movement, and the provisions that must be made in consequence, that causes most of the difficulty as regards the joint. After making allowance for the movement occasioned by variations of temperature, the joint (which would otherwise be the weakest part of the track) should be strengthened by bringing the joint ties closer together (those ties being generally of greater area than the others), and by efficiently securing the ends of the rails by fishplates, bolts and lock nuts, with the view of rendering the joints of not less strength than the remaining part of the track.

The conclusions to be drawn from the numerous replies and remarks by engineers throughout the English-speaking countries are as follows:

1. There is a maximum length of rail somewhere between 33 ft. and 60 ft. which should not be exceeded; and continuous or welded joints over a long length of railway are impracticable and dangerous.

2. To attain a satisfactory joint, it is of primary importance to have a strong and substantial rail.

3. In general a suspended joint is preferable to a supported joint.

4. Much remains to be done to perfect bridge and other special joints.

5. In designing a joint, economy in the first cost and maintenance must be taken into consideration.

6. Whatever form of joint is used, perfect drainage and strong under and upper ballast are necessary, as well as constant attention by the trackmen in adjusting the bolts and tamping the ties.

Surveying Conveniences.

By E. N. MILLEN.*

As my surveying practice is mainly confined to a hilly region a saving in weight of equipment is an important consideration. To this end I use a transit which with its box weighs only 13½ lbs. The telescoping tripod which goes with it, weighs, including cover, sling strap and shawl strap just 9 lbs. An 18-oz. rod and 20-oz. Marble axe with field book and stadia computer complete my outfit for farm surveying. When there is leveling to be done with some considerable degree of accuracy, I substitute for the 18-oz. rod a Chicago rod, 12½ ft. long, folding to 4½ ft. and weighing 5¼ lbs. with its canvas cover. This rod is as useful for stadia work as for leveling, and as good as it is inexpensive. With the above outfit one can go out alone, climb on and off trains in safety and, when necessary, carry it for miles with comfort.

Now let us take up the items of this outfit in detail. In work demanding extreme accuracy one needs a "full grown" transit, for weight tells in steadiness, but for a mixed town and country practice the lighter instrument if well made is up to every requirement. There is much in having the right kind of a tripod. The one which I use, a Gurley of medium weight with adjustable legs, is really a sturdy affair, and if the legs are placed with ordinary care is steady in a gale. The instrument itself, the second one of the kind that I have used, is also a Gurley and has most of the up-to-date attachments. Of course the graduations are not as large as on a full-sized transit, but, then, most of us use a reading glass anyhow, so that matters little.

I long since discarded the chain for farm surveys and only use a steel tape for town work. The necessity of always having a trained man with me in order to have the chaining properly done turned me years ago to the use of the stadia, and I have found it highly satisfactory in this region, where most of the land stands up on edge.

A recent survey of a 200-acre farm of very irregular contour shows an error of one link in longitude. This was done with the aid of an inexperienced rodman and is closer work than I ever did or knew any other surveyor to do, with a chain, on like ground, with as large an area. It is far easier to teach a man to hold a rod plumb than to train him to do good chaining. When you do your own measuring you can be as careful as you please. When I began using the stadia my instrument was fitted with disappearing wires, but this arrangement proved unsatisfactory. The changes from the ordinary cross wires to the stadia wires, and getting the focus adjusted involved entirely too much time and patience. There are other advantages in having both sets of wires in focus at the same time. For instance, to save the annoyance of carrying a long and heavy rod I now use half the stadia intercept on a 5-ft. rod, divided in 6-in. sections, the upper one to tenths. With a little practice the hundredths are easily and accurately estimated. This rod I had turned, of ash ¾-in. in diameter, and a handy machinist around the corner turned out an excellent point and screw joints for it. The dividing I did myself, staining the alternate sections with red ink so that the grain of the wood shows throughout, making when shellacked a very neat rod. It weighs 1 lb. 2 oz., and takes up practically no extra space, being packed between the folded legs of the tripod.

The cloth cover of the tripod I have fitted with a sling strap, so that with the light tripod hanging back of my left shoulder there is always one hand free to steady one's self with in getting on and off trains. The tripod is also bound with a light shawl strap so that it may be carried in the hand at times. The light steel reel of my 100-ft. tape is also fitted with a sling strap so that it is carried with little inconvenience. The little axe is carried by the rodman on its sling or in a pocket. An extra plumb bob with inside reel, and used for various purposes, hangs in a leather pocket, shaped to it, from my belt. A similar leather socket buttons on to one of the thumb screws at the upper end of the tripod legs, and into the socket the plumb bob of the transit is dropped when moving from station to station. This plumb bob pocket is made of a good piece of medium weight harness leather, well soaked in water and sewed closely around the tapering part of the "bob" with the top cut off in such a way that the upper edges will be ¼-in. above the bulge or largest diameter of the "bob" on one side and an inch higher on the opposite side. This makes provision for fastening to the tripod. For this purpose I use a brass ring cut on one side and opened about 3/16-in. When slipped through a couple of holes punched in the projecting upper lip of the pocket and buttoned over the head of one of the thumb screws this makes a very secure and handy fastening.

I usually take a reading glass out of its case and mount it in leather, for the case often disturbs the needle. This leather case carries a brass ring to which is attached a leather thong about a foot in length, the opposite end of which is made into a loop an inch or so in length carrying a brass hook. This loop is buttoned over another of the tripod thumb screws and the reading glass hung on to the brass hook by its ring when moving from point to point. What I like to avoid is the necessity for feeling through a multiplicity of pockets for the pencil, magnifier or other articles that I want to use. Another appreciated convenience is a field book with a flap and pencil holder. Personally I prefer Hodgman's well-bound field book with its handy tables and tuck.

A quick and handy plumb bob adjuster I have not yet found in the market. One of the hooks stamped out of sheet brass which tailors use in the waistband of trousers makes an excellent contrivance for this purpose of holding the plumb line at any point. A small brass wire hook fastened to one of the eyes of the flat, pantaloons hook makes a ready means of hanging in on to the little chain of the transit center, while the free end of the plumb line is tied into the other eye. With a pair of nippers nearly close the two sides of the trousers hook and then a very slight pressure on the cord will make the hook hold it securely at any desired point, and this with little wear on the cord. A slight coating of shoemaker's wax adds greatly to the life of a plumb line.

Another convenience for the man who uses the stadia is Cox's stadia computer. This is a circular disk so divided as to give the horizontal distances and difference of height of slope measurements. This contrivance is worth making up in metal. As now mounted with pasteboard covers about 7½ ins. square, it will not fit many pockets and is liable to buckle when carried I cut mine down to an oval about 5½ ins. the long way and mounted it between two firm pieces of harness leather hinged together. As thus modified, the computer can be carried in any coat pocket and will stand much rough handling.

One thing more: The Starrett Co., of Athol, Mass., made for me a square for plotting from latitudes and longitudes which is a great convenience. It is graduated to four scales on the outer and inner edges, so that by placing the edge bearing the scale desired on a meridian the latitude and longitude of any course can be rapidly checked off very accurately with one placing of the instrument.

*48 Trinity St., Newton, N. J.

Rail Grooves and Track Gage for Curves in Street Railway Track Laid with Grooved Rails.*

By C. W. L. FILKINS.†

The primary principle on curves laid with grooved rails is that the forward inside wheel of a car truck shall bear against the inside guard and the rear outside wheel against the outside guard, thus keeping the flanges of all of the wheels clear of either rail head and eliminating the side-wear on the heads. In practice this is impossible, due to irregularities, and could not be maintained, due to the wearing of the guards. The ideal conditions would be new wheel flanges and a particular rail for every curve, wheelbase and flange, but this is prohibitive owing to inaccuracies in wheel setting, different flanges and wheelbases over the same track, and most particularly to the necessarily limited number of types of rolled guard rail sections.

Having a fixed rail groove, it is desired to know if that groove will properly serve under the given conditions, or how to alter it to meet them. Let us find the minimum groove in which a given wheel flange will run, on the assumption that the equipment is geometrically perfect. In a car traversing a curve, the longitudinal axis of the car truck is normal to the radius of curvature of the track drawn to the mid-point of the truck, the wheels being held rigidly parallel to the axis. The portions of the wheel flanges which determine the size and shape of the minimum groove are the portions below the level of the wheel-tread. If we project these portions of the flanges upon a radial plane, we obtain the contours of the minimum grooves.

It is premised that the inside guard guides the truck around the curve. It is reasonable to limit the range of irregularities in wheel setting to ⅛-in., or ¼-in. to each wheel, distributing 1/16-in. on each side of the normal position of the wheel. Since this variation may occur simultaneously to double the effect, there is a ⅛-in. change outward and inward from the normal position of the outside wheel flange. The outward movement will seldom require attention as it will be taken up probably by the fillet and riding on the head of the outside rail, and practice indicates that irregularities in that direc-

*Abstract of an appendix to the report of the Committee on Way, presented at the annual meeting of the American Street and Interurban Railway Engineering Association, at Denver, Colo., Oct. 4 to 8, 1909. We omit the mathematical discussion and the consideration of individual forms of grooves in grooved rails for street railway track.

†Wm. Wharton, Jr., & Co., Philadelphia, Pa.

tion are rare. The inward movement of ⅛-in. must be provided for by holding the outside guard back, thus increasing the width of the outside minimum groove by that amount for practical purposes.

From grooves which have been plotted, we are enabled to note the effects of variations as follows:

(1) The width of the groove increases directly with and in the same amount as the width of the wheel flange.

(2) Increasing the depth of the wheel flange slowly increases the width of the groove, depending greatly upon the form of the flange in obtaining the increased depth.

(3) The effect of wheel radius upon the grooves is negligible for the present range of wheel radii.

(4) The effect upon the grooves of different track gages from 4 ft. 8½ ins. to 5 ft. 4½ ins. is inappreciable.

(5) The factors, outside of the wheel flange, which critically affect the grooves, are the length of the wheel-base and the track radius.

(6) For track radii greater than 100 ft., the minimum groove is practically the same as the flange section.

(7) The effect of the gage is to make the width of the outside minimum grooves about 1/16-in. less than for the inside; hence the practical outside groove, allowing ⅛-in. for play, should be 1/16-in. greater in width than the inside minimum groove.

For uniform practice it is suggested that in the case of a widened gage the gage-line of the inside rail be made to conform to the geometrical position of the standard gage-line and the outside rail moved outward the amount the gage is to be widened. Geometrical purposes would thus require that the gage narrow abruptly at the points of tangency, even though not carried out in practice. One of the usual methods of eliminating this widening in the neighborhood of tangents is to narrow the gage of the curve as it approaches the tangent; another is to carry the widened gage through onto the tangent and there gradually narrow down to the standard.

As a matter of fact, the gage of the curved track contiguous to the tangent and the gage of the tangent should have an increased widening, as compared with the more central portion of the curve, as the straight track acts as a curve of increased radius in conjunction with the curve. This additional widening could be accomplished very effectively by giving a slight curve to an extension of the inside rail into the straight track, commonly called the straight guard on the end of curves.

In conclusion, we might summarize as follows for the flanges in use at the present time and provided the wheels are set ¼-in. less than standard gage at a point ¼-in. below the level of the wheel tread; also allowing ⅛-in. for tightening of wheel gage due to irregularities in wheel setting:

(1) There will be no widening of the standard track gage when the width of the rail groove does not exceed that of the required inside groove.

(2) If the width of the rail groove exceeds that of the required inside groove, widen the gage the amount of excess.

(3) If the rail groove be too narrow, plane the inside head to give the width required for inside groove and the outside guard to give a width of 1/16-in. greater than that of the planed inside groove.

(4) If the rail groove be of correct width for the inside groove, do not widen the gage, but plane the outside guard to increase the width of rail groove by 1/16-in.

(5) For the range of radii in common use (not less than 25 ft.), there will be no narrowing of standard gage.

(6) For a given rail, the widening of gage is greater the longer the track radius.

(7) When the outside rail is not guarded, the statements as to widened gage still hold, but obviously the planing of the outside guard need no longer be considered.

Practice will call for some modifications in the application of these theoretical conclusions, as it is obviously impracticable to change the gage for every radius of curve in a layout. The tendency should be, therefore, towards selecting a rail with a groove most nearly suitable to the combination of conditions, or to plane the groove to suit where necessary, and lay the curve to the standard gage.

Where cars with different wheel-base and wheel flanges traverse the same curves, the combination calling for the widest groove must govern the groove; and the combination calling for the narrowed groove then applied to the wide groove must govern the gage, with extra allowance in the width of the outside groove equal to the widening of the gage.

Col. Smith S. Leach.

We briefly recorded in our last issue the sudden death of Col. Smith S. Leach, Corps of Engineers, U. S. A. We are now able to present a recent portrait of Col. Leach and a fuller account of his professional career. Col. Leach was born in Indiana on April 27, 1853, and was appointed to the Military Academy from that state in 1871. While at West Point he distinguished himself in his class, graduating at its head and serving as First Captain of the Corps of Cadets during his final year.

After graduation he was stationed for seven years with the Battalion of Engineers at Willett's Point, N. Y., except for a few months in 1876, when he was detailed for duties at the Centennial Exposition at Philadelphia.

In July, 1878, he was made Recorder of a Board of Engineers on the Improvement of the Mississippi and Missouri Rivers and a year later

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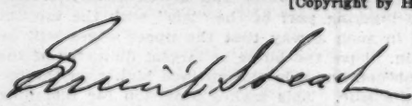

he became Secretary and Disbursing Officer of the Mississippi River Commission, with headquarters at St. Louis. While in this position he effected a complete systematization of the surveying work of the Commission and of its purchasing department.

After nine years at St. Louis he was transferred to the Memphis district, where he remained until 1890. During this period he had a short assignment to duty at Washington as Assistant to the Engineer Commissioner, and for two years he was charged with responsibility in connection with the Memphis Bridge construction. While he was in charge of the Memphis district, he did some important work in developing mattresses of a width of 300 ft. to protect the banks of the river.

After two years as Assistant Engineer at Boston, on the harbor defenses there, he was transferred to the northern district and placed in charge of Lake Champlain and the St. Lawrence River. At this time he devised a very ingenious system for detecting for removal small rocks in the channel of the Niagara River. This he effected by means of a sweeping machine of his own invention, which would indicate the location of any obstruction in the bed of the river.

In 1896, he was transferred to New London, Conn., where perhaps his most notable professional work was done in connection with the fortification and river and harbor work at the eastern end of Long Island Sound. He originated the idea of protecting New York City by fortifying its entrance from the Sound by seacoast defenses, and to this end he devised a type of battery suitable for use upon the small islands at the western end of the Sound.

After six years at New London, he was placed in command of the First Battalion of Engineers at Fort Leavenworth, Kan., where he exhibited one of his especially strong characteristics, his intense interest in the military side of his profession. While at Fort Leavenworth he did fine work in developing the organization and equipment of the Battalion, and was one of the first to show in a mixed brigade post what engineer troops could do to develop the efficiency of a mobile army.

It was largely as a result of Col. Leach's record at Fort Leavenworth that he was attached in 1904 to the General Staff at Washington, where he was put in charge of Fortification, River and Harbor Work, in connection with which he took up the unfinished Washington filtration plant and carried it to completion. Under his direction the force was organized and the actual work of filtration commenced. As a result of his organization, the work is being carried on at a cost of about $82,000 a year as against the original estimate of $105,000.

From 1907 to the date of his death, Col. Leach was Assistant to the Chief of Engineers, being assigned during the past summer to duty as a member of the River and Harbor Board.

His health during the last year has been very poor and for six months of the time, in fact, he was away from Washington on leave of absence. He leaves a widow, but no children.

Col. Leach was one of the most beloved of engineer officers, and it was largely through this feeling of affection on the part of his subordinates, caused by the personal regard and respect in which he was held on account of his high character, that he was able to accomplish so much in the various stations which he occupied. This characteristic, joined to his great administrative ability and his marked originality in design makes his death a great loss to the Service.

Perhaps the greatest memorial of his ability is the "Engineer Field Manual" (Professional Papers No. 29), which he compiled at Fort Leavenworth. The original edition of 2,000 copies was almost immediately exhausted, and he was at work at the time of his death on a second and enlarged edition, the proofs of which were in his office.

STREET RAILWAY SUBWAYS IN CHICAGO are proposed by two contracting firms, both of whom have applied to the city authorities for consideration of proposals to construct complete systems of subways, and for opportunity to prove their financial ability in the matter. These propositions have been made by George W. Jackson and M. H. McGovern, respectively. The former has plans of his own, while the latter proposes to follow the plans prepared by city's engineers, which plans were described and illustrated in our issue of June 3, 1909.

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The electrification of the Illinois Central Ry. terminal lines in Chicago as demanded by the city (and discussed in our issue of Oct. 7) has been rejected for the present as the result of the vote of the stockholders upon this question at a meeting on Oct. 20. In bringing pressure to bear upon the company, the city authorities had requested the President, Mr. Harahan, to submit the question to vote, but in doing so Mr. Harahan presented a report in which he pointed out the special difficulties in both engineering and traffic conditions, the uncertainty of the results, and the great expense that would be involved. Two of the greatest difficulties are due to the facts that (1) other railways use the Illinois Central Ry. terminals and there is a very heavy interchange traffic, and (2) main line and suburban passenger tracks and freight tracks and yards are all included in the terminal system. This latter condition makes it difficult to separate traction systems and enormously expensive to equip the entire system for electric traction, while serious difficulties and dangers would be introduced in the operation of yard and switching service by electric traction.

The city now proposes to attempt to force the railway to adopt electric traction by means of local ordinances. It is proposed even to apply to the state legislature for additional compulsory powers, though it is considered doubtful whether (in view of unfavorable action on somewhat similar requests) such powers would be granted. It has been pointed out also by some of the city's legal advisers that mandatory ordinances aimed at this one road would probably be held as discriminatory or unconstitutional by the courts, and it is now proposed to broaden the scope of these ordinances to cover all railway lines within the city limits. The first draft of the proposed ordinance actually required all these lines to be equipped by January, 1912, which shows how little those preparing the ordinances know about the work and its limitations.

Both the city and the various business and social organizations which are agitating this matter are working on the assumption that the railways (or one railway in particular) should be compelled to incur an enormous expense in order to eliminate the smoke nuisance due to steam locomotives. The "punishment" is out of all proportion to the "crime," and the proposition might be considered as ridiculous, but for the serious results which may attend it.

That the smoke is a nuisance, nobody will deny; and that it is the duty of the railways to do all in their power to reduce or eliminate their share of the nuisance, is appreciated by the railways themselves. But much of the locomotive smoke is emitted in manufacturing districts where the nuisance is a minimum. One of the primary causes of the trouble is that the Illinois Central Ry. passes for a part of its length through a residence district, and the people object to the noise and dirt from the engines. The objection is natural, but it is unreasonable to make this a basis for saddling the railways with the enormous cost of converting the entire terminal system to electric traction. The city itself is a frequent offender against its own smoke ordinances, through the agency of its schools and other buildings. Business and office buildings, factories and industrial plants are great and chronic offenders, but it appears to be a spectacular and popular matter to concentrate the attacks upon one railway (or upon the railways in general if the first plan is found to savor of persecution). The city is insistent upon electrification, paying no heed to other methods of reducing the locomotive smoke nuisance, although it was pointed out in Mr. Harahan's report to the stockholders that:

> The elimination of smoke to meet all reasonable public demands can be accomplished without the use of electric traction.

The ethics of the case were discussed carefully in our issue of Oct. 7, while the city's proposition for the electrification of the Illinois Central Ry. was described in our issue of Dec. 24, 1908. It must be remembered that the railway company has had this matter under consideration since 1891, when the introduction of electric traction for the suburban service was investigated by Mr. John F. Wallace, M. Am. Soc. C. E., then Chief Engineer. Then, and at other times, it has been found that while the plan might be practicable it would not be economical. Even with the improvements in electric traction of recent years, careful estimates indicate that there will be no economy in making the change for this service, while the conditions as to the including of main line, freight and yard work are unprecedented. At any rate, the railway company has decided that with due consideration of its duties to the public on the one hand and to its stockholders on the other, it cannot undertake the electrification of its lines at this time.

With the very praiseworthy desire to reduce the cost of small dwellings so that a degree of comfort and cleanliness can be secured by the householder of extremely limited means, a few men in this country are trying to perfect a concrete house which can be cast in one operation inside a set of molds to be used over and over again. Mr. Thomas A. Edison's catholic mind some four years ago saw the possibilities in this one-piece house, and his admirable publicity department since then has not allowed the idea to be confined to his laboratories where tests have been conducted with ever promised but hardly realized success. In consequence the reading public, influenced no doubt by Mr. Edison's successes in other fields, is quite ready to believe almost anything about the economies, beauties and durability of the molded building.

For the engineers and architects engaged in studying this question we have no criticism, although we think that the difficulties of the problem they have attacked will engage their attention for a somewhat longer period than they now anticipate, but we do wish to deprecate the rash manner in which the lay press is exploiting the matter, and bestowing lavish praise upon a proposition which is not yet beyond the experimental stage. Heretofore prominence has been given entirely to the Edison patent, but in the Oct. 2 number of "The Survey," a New York weekly devoted to sociological and philanthropic progress, there is a very laudatory article describing a house, quite similar to that of Mr. Edison's, particularly in the fact that, by virtue of the great number to be molded from one set of forms, the cost will be reduced to about $1,200 for a house costing under present methods two or three times that amount.

The dwelling shown in "The Survey" is quite worthy of praise from the sanitarian's standpoint. It is light and airy, easily cleaned and, for the use for which it is intended, reasonably good looking. But the prime advantage claimed for it is its cheapness, since it will be admitted that for a sufficient sum, fairly reasonable as present costs go, houses can be, and in fact are being, constructed equally as serviceable as the molded house. This cheapness is brought about mainly by two items, the reduction in cost in forms due to their repeated use and the reduction in labor, due to the rapid pouring of the walls and floors, to say nothing of fixtures, as a unit. Neither of these have been tried outside of a laboratory, and never on a large scale. Even granting that the main structural elements of a house can be poured from a few openings in one operation—and that is something few engineers with experience in concrete construction will concede—there is every reason now to believe that it will be practically impossible to construct forms which can be placed and removed at small labor expense and which, at the same time, can stand the hardships of usage long enough to reduce the first cost per house to the desired minimum.

If this can be done at all, it is something which must come as a gradual development through actual construction and not as the result of theory plus laboratory experiment. We are far from denying that there are possibilities in cheap concrete dwelling construction in the hands of men who understand the business and who know the best roads by which to move forward. What we would emphasize is that possibilities are not yet actualities, and that success is more likely to be attained by simple methods than by any complicated and revolutionary process.

American engineers in municipal service who think—and often with good reason—that hard work and faithful service receives small compensation, may be interested to know on what scant allowance those engaged in municipal service in Great Britain have to subsist.

We clip the following items from the "Personal" column of the London "Contract Journal":

> Warrington Town Council have increased the salary of their assistant water engineer, Mr. James Gray, to £162 per annum.
>
> Mr. James Brown has been appointed sanitary inspector to the Stockport Corporation, at a commencing salary of 35s. per week.
>
> The Chelmsford Rural District Council have increased the salary of their surveyor, Mr. G. F. Andrassy, by £10 per annum.
>
> The West Lancashire Rural District Council have increased the salary of Mr. Robert R. Rosbotham, assistant surveyor, from £85 to £110 per annum, that of Mr. J. Wignall, assistant surveyor, from £110 to £125, and that of Mr. H. Carr, chief surveyor's clerk, from £30 to £52.
>
> Mr. J. E. Blackwell, district council surveyor in Derbyshire, has been elected county surveyor for Cambridgeshire, in succession to Mr. Smith Rowley, resigned, at a salary of £400, with £180 for motor. There were 230 candidates for the post.

A raise of a dollar a week in the salary of a responsible public officer is deemed worthy of a "Personal" item! Is it any wonder that in a country where the struggle for existence is so fierce, the proposal to shift part of the tax burden to the holders of vast inherited fortunes should receive popular support?

A great deal—and not too much—is being said in these days about the need of executive ability in the engineering profession. An illustration of the fact that American engineers in the past have been noted for their achievements as leaders of men is given in the address by Gen. Grenville M. Dodge, which is printed in this issue, describing early engineering work in the building of the Pacific railways and in the Civil War. The address was delivered last winter before the Western Society of Engineers, and, like numerous other things which are so good that they are as well worth printing at one time as at another, has had to wait until space was available in our pages.

Gen. Dodge paints a vivid picture of the heroism and loyalty of the engineers who pushed civilization ahead on the Western frontier forty years ago; but we are by no means sure that equally fine qualities of manhood and mettle are not being shown in some of the pioneer works that engineers are now carrying forward, in the Canadian Northwest, in the Philippines or in South America, for example. Of course it is true that the great development of engineering has created many lines of industry where the ability to do steady humdrum plodding work is the main thing, and there is little opportunity for personal bravery or original resource in adapting crude materials to untried conditions. None the less, we believe that the engineering profession has not deteriorated and that where the need and opportunity exists for such heroic work as that which General Dodge describes, men will be found to-day as competent to undertake it as were found in the '60's.

The unfortunate experiences of Mike Flannery, the express agent, celebrated by the author of "Pigs is Pigs," who received—and held—a consignment of guinea-pigs, are recalled by the following recent decision of the Interstate Commerce Commission:

> The agent of a shipper not knowing the value of a dog to be sent by express, nevertheless named a valuation of $500, and the resulting charges to destination amounted to $45. The dog was actually worth $15, and at this valuation the express charges would have been $8. The consignee declined to accept delivery and pay the charges demanded. Upon inquiry whether charges may be collected on the basis of the actual value of the dog, it was held that the shipper is responsible for the act of his agent and that the charges at the valuation given must be collected.

That decision may be good law, but it seems like setting too high a standard of attainment for all parties concerned, including the dog. It is a pity we are not informed what disposition was finally made of that unhappy animal. Suppose—what seems very probable—that the consignee refused to pay $45 express charges on a $15 dog? Did the dog remain in the custody of the freight agent until his appeal reached the ears of the Interstate Commerce Commission? If so, it is safe to say he is now too old a dog to be taught new tricks, and hence his value may now be much less than $15. What does the Commission advise the Accounting Department to do with the uncollectable express charge and the charge for board and lodging for a $500 dog while his appeal has been pending? Apparently this is a case where a charge to the "yellow dog account" would be justified.

There have been many attempts to formulate an explanation of a steam turbine's operation which will be understandable by the non-technical man. One of the simplest we have seen is given by the "Daily Star" of Lincoln, Neb.

> The turbine stands about 6 ft. high and is about 6 ft. through. It is cylindrical. The turbine wheels inside are used to keep the acids and zinc stirred so as to generate electricity rapidly.

This was contained in a comment on an accident to a turbo-generator. No wonder it blew up!

Why Not Reduce the Delays to Freight Shipments?

The freight car surplus, which has persisted ever since the panic of 1907, has finally disappeared with the rush of traffic due to handling the fall crops together with the business resulting from activity in the iron and steel industry and in building construction. In place of the car surplus, reports now come in of car shortage in various parts of the country.

There seems to be hope that the railways may give this matter of car shortage more intelligent consideration than it has received in the past. The splendid work of the American Railway Association's Committee on Car Efficiency, under direction of Mr. Arthur Hale, has made clear to railway officers that car shortage is as much affected by *car efficiency* as it is by the number of cars owned.

During the past two years while there have been strings of idle cars ready to draw upon to fill shippers' orders, there has been no great incentive to work for high car efficiency; but now that cars are in demand, it is up to the freight traffic managers to see how rapidly they can keep their equipment moving.

There has been a great deal of published discussion concerning the efforts of the railways to reduce the delays to cars on delivery tracks by the imposition of demurrage charges for each day the car is held by shippers beyond a fixed free time. No one who gives serious study to the subject can question that proper and reasonable demurrage rules and charges are as much to the interest of the general public and the shippers themselves as they are in the interest of the railway companies.

But there is a great opportunity to reduce delays in car movement after the car starts on its journey. The average distance traveled per day by the average freight car on the railways of the United States is only about 22 miles, according to the statistics of the Car Efficiency Committee. If we exclude the idle cars from the total to obtain the movement, the average even then is only 25 miles. Taking average speed of freight trains on the road at 10 miles per hour, that means that the average freight car is moving on its journey *only 2½ hours out of the* 24. All the rest of the time it is standing idle in some yard or on some siding. Is it any wonder that freight yards are congested? Is it not a pertinent inquiry whether, instead of building more cars and bigger yards to handle increased traffic, better results might not be attained by overhauling our methods of moving—and not moving—freight traffic, and finding some way to keep freight cars moving, so that they may reach their destination more promptly and get out of the yards where they are now held.

Not all the red tape is used in the Departments at Washington by any means. At a recent meeting of the Western Railway Club, an officer of the Chicago, Burlington & Quincy R. R. pointed out how present car interchange rules delay car movement. The subject is far from being a new one, but it deserves more attention from railway managers than it has yet received. It is absurd on its face that a question between two railway companies as to which shall spend a dollar or so for repairs to a freight car should delay a carload of freight from 24 to 48 hours, and should cause often an actual expense of several dollars in idle car time and work by switching locomotives, to say nothing of yard congestion.

The fact is that the length of time occupied by the average railway freight shipment in its journey from sender to receiver is one of the most serious defects of American railway practice. When a shipment has to traverse the lines of several different companies and pass through important junctions, it is the usual thing to have a shipment take from one to three weeks to make a journey of as many hundred miles. Those who urge the superiority of water transportation to rail have good ground for their claim that, between important centers, freight sent by water will reach the consignee more promptly than that sent by rail. This delay in forwarding shipments not only means poor service to shippers but added expense to the railways. It is the *delay* in handling freight that is responsible for crowded yards and transfer houses and low car efficiency. Prompt handling of small merchandise shipments by freight would transfer to the railways millions of dollars in business which now goes to the express companies.

It is very likely true that under American conditions we cannot expect to equal the prompt freight service of English railways where a parcel shipped by freight from Birmingham, for example, is delivered the next day in London. Our larger cars doubtless make it more difficult to handle small shipments promptly without loss through the movement of cars carrying small loads. But even though we cannot equal the English practice, there is room for us to do vastly better than is now done. Improvement in this matter ought to mean a saving in operating expenses. At least it might save a large outlay in increased rolling stock and enlarged freight yards which seem to be necessary if present methods are followed.

How Much Ought American Railways to Spend on New Passenger Stations?

With the increase in railway revenues resulting from the revival of business and consequent growth in traffic, there comes a revival of planning for railway extensions and betterments. At the present time there appears to be particular activity in the planning and building of new passenger stations.

It began, of course, as all such things begin, with the large cities. In New York the Pennsylvania R. R. completed in July the construction of its enormous and enormously costly new station in the heart of Manhattan which covers over 25 acres of ground. It is now engaged in furnishing and equipping the building, tracklaying, etc., and expects to be ready to operate the first trains into the station in January. Near by the New York Central is steadily working away at its huge station which with the adjacent yards is to cover a total area of over 48 acres.

Land in the center of Manhattan, where these great passenger terminals are located, is worth fabulous sums. Within a few weeks property within two blocks of the New York Central station has changed hands at a price representing about $175 per sq. ft. The land alone for these new passenger terminals represents as large an investment as the total capitalization of many good-sized railway companies. And besides the land there is the vast expense, amounting to many million dollars in each case, of constructing and equipping the stations.

The magnificent new union station at Washington has probably been no small factor in stimulating a public demand for better passenger stations. Washington's near neighbor, Baltimore, concluded last spring that since Washington had so fine a station, Baltimore deserved something proportionately good. There was vociferous agitation in Baltimore to have the Pennsylvania R. R. spend two and a half million dollars on a new passenger station. A compromise was worked out by which a half million dollar station was, rather grudgingly, accepted.

Kansas City has outgrown its present union station. A new building is to be erected there at a cost of not less than $3,000,000. At Chicago a recent press report states that a new union depot is to be built for the joint use of the Pennsylvania, Burlington, St. Paul and Alton systems. The cost is given as $25,000,000 but due subtraction may be made from this sum for newspaper exaggeration.

At Montreal it has been recently reported that the Canadian Pacific will spend a million dollars or more in reconstructing its Windsor St. station and the Grand Trunk will spend two million dollars in rebuilding its Bonaventure station and the approaches thereto. At Detroit the city authorities and the Michigan Central R. R. officers have been in conference over the construction of a new six-million dollar depot. At Cleveland, also, a union station of approximately equal cost is projected.

These are instances, taken at random, of some of the current projects for great new railway passenger stations in the large cities. There is equal activity in the demand for new railway stations in cities of moderate size and in the smaller towns. It could not well be otherwise. If one city has a new passenger station, its business rivals at once clamor for something equally as fine. The very fact that such vast expense has been lavished on the great new stations at Washington and at New York City is taken to prove that the railways can afford to spend money proportionately to improve all other stations down to the smallest. Very strong pressure is brought to bear upon the railway companies to undertake the building of new stations.

Now we are far from denying that new stations, cleaner stations, and more convenient and commodious stations are needed to accommodate railway passenger traffic in hundreds of cities. But so are a dozen other radical improvements in railway lines and equipment. It is a fair question, and one to which the public ought to give a fair hearing, how much the railways are

justified in spending on new passenger stations. Let us not forget that somebody must pay for these new stations. Is the money for them to come out of the pockets of the stockholders in the shape of reduced dividends—where there are any dividends to reduce—or shall the traveling public which has the use of these stations pay for them in increased rates of fare?

And this question is the more important to discuss at the present day because of the changed relations between the railways and the public. The public once humbly petitioned, if it made any remonstrance at all; but in these days it demands with authority. Let us draw the contrast even more forcibly. It occasionally happened, in the days of Western boom towns, that the hustling city of "Tropolis" thought its boom ought to be coaxed along by the building of a fine passenger station. So the Mayor of "Tropolis" and a delegation from its Board of Trade would make a long journey and wait humbly in the anteroom of the Railway President's office until that great man was ready to receive them. And usually the delegation very shortly found itself out in the street again with the "Tropolis" boom all shriveled up.

How different it is now! When the Tropolis citizens have talked over their desires for a union station and read the editorials in the Tropolis "Banner" demanding that "this fair city receive from the railway company the recognition that is her due," they send a petition to the State Railway Commission. And the State Railway Commission *orders* the railway company to appear at a stated time and place and answer the petition from Tropolis.

This is not an exaggeration. Several cases have come to our notice recently, where petitions for a new station are being heard before State Commissions. The railways cannot ignore these demands if they would. The question arises what ought they to do, and what ought State Railway Commissions to do, when the responsibility for a decision is laid upon them?

At the outset let us say that we fully recognize the obligation on the part of the railway companies to provide "reasonably good" accommodations for passengers at its stations. And we recognize also that this definition is open to just as elastic an interpretation as the statutory provision that all railway rates must be "reasonable."

What is "reasonably good" accommodation for passengers? Without doubt the answer would vary vastly at different times and different places. Reasonably good accommodations in 1880 might be very mean and out of date measured by the standards of 1910. So, too, no one could expect the same grade of passenger accommodations at Oshkosh that is furnished at Minneapolis, or anything at a country village resembling facilities at Oshkosh.

The railway company ought to provide reasonably good accomodation at the passenger stations, suited to the importance of the station, the character of traffic it has to handle, and let us add to the pocket-book of the road and of its patrons. But when it has done this it has done all it can be expected to do. More; it is very doubtful whether railway officers can go beyond this without infringing upon the rights of their stockholders or of travelers and shippers.

There is a widespread idea, and not an unreasonable idea, perhaps, that a railway station ought to be one of the important public buildings of a city. It is in modern times the real entrance gateway. Why not make it an architectural adornment, as was done with the gateways which pierced the walls of mediaeval cities?

We have no quarrel with this idea; but if the idea is to be carried into execution, then the burden of expense should be borne by the city and not by the railway company. We do not mean that a railway should not make its stations good pieces of architecture. Certainly it should do this, as should every other citizen in proportion to his means, his ability and his taste; and a railway company ought to have better taste and greater ability to secure good architecture in its buildings than the average citizen. But when it is has done this, it has done all that can be reasonably expected.

But is it not a fact that a large proportion of American passenger stations are architecturally bad, more or less uncomfortable and as a rule profoundly dirty? We have no doubt of it; but the same thing is true of the average public or private building. Are the railways obliged to reform any faster than the rest of us?

The most serious aspect of this question of expenditure on passenger stations is the financial aspect. The unfortunate fact is that the investment which a railway makes in passenger stations beyond what is *necessary* is an investment which returns no revenue. On the contrary, it involves a perpetual burden for annual maintenance.

We are aware that the stereotyped reply to this statement is that such improved facilities stimulate traffic; but the unfortunate thing about this answer is that it is not true. Of course it is easy to point to traffic figures before and after the completion of a new station and imagine that the figures prove something; but such figures can be matched by numerous cases where traffic has grown by leaps and bounds notwithstanding the fact that passenger stations remained all the time cramped and dirty and out of date. The great bulk of passenger journeys are made for business or necessity. Even when people travel for pleasure, they will not stay at home because the railway station where they take the train is disagreeable; nor will they decide to go because the station has all the luxuries of a first-class hotel.

Of course the old argument will be brought up of the competition between the different railways and how the railway with the finest stations will attract traffic away from its rivals. Competition in railway traffic, however, is a passing phase. What little competition still remains in the railway business is bound soon to disappear. And from the standpoint of the public interest it is not advantageous that an undue proportion of railway earnings shall be spent on passenger stations in order that passengers may travel on one road instead of another.

It is a fact which ought to be fairly and squarely faced that money spent on fine passenger stations is a luxury. It is a luxury because it yields no return on the investment and requires a perpetual annual outlay for care and maintenance, and let us not forget—for the payment of taxes.

Almost every other outlay which a railway makes in improving its property is made with a view of receiving a return on the money invested in the shape of reduced cost of moving traffic or increasing the volume of traffic. But expenditure on passenger stations, in excess of moderate and reasonable requirements is an investment which is a burden instead of a benefit to the property.

How, then, ought expenditure on a new station to be financed? Ought it to be added to the capital account? This is the usual way, of course; but is it sound financial policy to increase the capital of a concern on account of an expenditure which diminishes instead of increasing its earning-power? Suppose—as has actually happened—that an insurance company erects some huge monumental office building which proves unprofitable as a business venture so that it yields no net income. Would that building be carried at its cost in the company's assets? If it were, the fictitious item would be corrected as soon as the company's affairs were investigated by a competent accountant.

It seems to us that the fair and reasonable way of treating this matter of railway passenger station is to regard fine stations as a luxury. It is all right for the wealthy railways which are making large profits to devote some part of their current earnings to the construction of fine passenger stations year by year; but their cost should not be added to the capitalization. And on most roads other expenditures on improvements—improvements which will decrease expenses and add to revenue—improvements which will add to the safety of operation—ought to take precedence over expenditures for fine passenger stations.

On this matter we may well take a leaf from the practice of foreign railways. They far excel us in provision for the safety of passengers at stations; but the station buildings themselves are as a rule inferior to the good station buildings in this country. As for our finest passenger stations, the new station at Washington or the new Lackawanna station at Hoboken, not to mention the two great stations approaching completion on Manhattan Island, there is nothing to equal them in Europe or anywhere else in the world.

Reference may properly be made here to the European practice of incorporating hotels in the railway station building. Where this is done it is possible to derive some revenue from the station building. This has seldom been done on this side of the water except to some slight extent in Canada. The European railway hotels, however, find it difficult to hold the best and most profitable class of patrons on account of the noise, smoke and dust which is bound to be present, to a greater or less extent about a great passenger terminal. About the only successful use made of railway station buildings in this country has been for railway offices.

Are we not in this country inclined to give undue importance to the passenger station? How few travelers nowadays spend much time in a station. And they will spend less as the habit spreads in railway circles of running trains on schedule time.

We are perfectly well aware that popular sentiment runs counter to the ideas we are advocating. A fine station building is something which can be seen and appreciated by the public; and railway officers—contrary to the popular belief—are desirous of giving the public what the public wants. But the public is not always ready and willing to pay for what it wants. It wants 2-ct. a mile passenger fares for example; but if railways lavish money on expensive passenger stations, they can afford no reduction in passenger rates. Even as it is, a large proportion of the passenger traffic carried costs the railway companies more than the revenue which it brings.

As we said at the outset, we fully recognize the need for improvements in many American passenger stations. What we would urge is that the work in this direction be not overdone to the detriment of railway finances or to the neglect of other improvements which affect the public safety. It is the duty of railway officials without doubt to refuse many appeals for new railway stations, in the public interest as well as in the interest of their stockholders. And when there is sound reason for such refusal, the railway officers should have the backing of the state railway commission.

And one thing which not a few railways might do to great advantage is to clean up the station buildings they now have. It is the dirt and dinginess that arouses public condemnation. A few hundred or a few thousand dollars spent in new sanitary accommodations, in ventilating apparatus, in vacuum cleaning systems or in better lighting may so satisfy the public that the expenditure of tens of thousands to tear down old passenger stations and build entirely new ones will be unnecessary.

If the people of a city urgently appeal for a new station on the ground that it will be a municipal ornament, they may be reminded that the burden of paying for such ornaments ought to fall on the people of the city and not on the railway owners. In fact in one city of New England it was recently seriously proposed to issue bonds for $100,000 to aid in the construction of a new passenger station. If other municipal requirements are well taken care of, there could be no objection to this, if the voters approved.

There are few cities of the United States, however, where the need of better schools, better water or sewerage, better fire protection, better paved and cleaner streets, ampler parks and playgrounds and similar demands will not have a stronger claim on the taxpayers than projects to add to the cost of a railway station in order that it shall be a municipal ornament.

LETTERS TO THE EDITOR.

A Method for Computing Volumes.

Sir: In your issue of Oct. 7, in the letter of Mr. Charles B. Buerger regarding the volume of a groined arch, there is a typographical error in the formula for the volume. In the second line of the expression for the volume the coefficient 0.942 should be 0.9042 [the correction was noted in our issue of Oct. 14—Ed.]. The latter value is used in the example worked out, but a user would take the formula and not the example.

Mr. Buerger does not give his method of deriving the formula. In this case the method would be of more value than the special case given. A simple rule that can easily be carried under the hat is this: The volume of any solid of constant cross-section with plane ends not parallel to each other is equal to the area of the normal cross-section by the length between the centers of gravity of the end planes. In the case of the groined arch under consideration the rule may be applied thus: The cross-section (of the space below the arch) is a quarter ellipse, whose area is $\frac{1}{4}\pi$ multiplied by the semi-axes. The length for the arch a in the sketch is

$$s + e - \frac{4e}{3\pi}.$$

The latter is found by observing that the relation between the semi-axis of an ellipse and the distance from the center of gravity of the half ellipse (or semi-circle) to the center of ellipse (or circle) is $\frac{4}{3\pi}$.

The general rule given above for volume can be applied in a large number of cases. For example, the exact weight of an angle or channel or zee-bar cut off on a bevel in any direction can be found by multiplying the weight per foot by the length of the line through the center of gravity of the shape.

Edward Godfrey.

Monongahela Bank Bldg., Pittsburg, Pa., Oct. 8, 1909.

The Percentage of Angles in Plate-Girder Flanges.

Sir: Almost all specifications for plate-girder bridges contain a clause like this: "At least 50% of the flange area shall be in the angles, or else the largest size angles shall be used."

It has been the writer's experience that this specification is seldom followed in heavy bridges. The 100-ft. girders of the Lethbridge Viaduct on the Canadian Pacific Ry., described in your issue of Sept. 23, are a case in point. The make-up of the flange is not stated in the article, but the writer has been informed that it consists of two angles, 8 × 8 × ⅝ ins., three coverplates, 20 × ⅝ ins., and one coverplate, 20 × 7/16-in. Here the area of angles is 19.2 sq. ins., area of plates 46.2 sq. ins., so that only 29% of total flange area is in the angles, and 71% in the coverplates.

Not long ago the writer had occasion to examine the drawings for a heavy plate-girder highway bridge, built about ten years ago in a city of this state. The flange was composed of two angles, 6 × 6 × ⅝ ins., area = 16.9 sq. ins., and three coverplates 24⅜ × 1 in., area = 72 sq. ins.; 19% of the total flange area was in the angles, and 81% in the coverplates. In this girder ⅝-in. rivets were used.

C. H. Wood.

186 State St., Albany, N. Y., Oct. 14, 1909.

[The make-up of the Lethbridge Viaduct girders is correctly given above, but the designer also figured ⅛ of the web area as resisting the bending. This adds an area of 5.25 sq. ins. gross, which is counted as net flange area, making a total of $15.47 + 3 \times 11.25 + 7.88 + 5.25 = 62.35$ sq. ins. net flange area. The make-up was inadvertently omitted from our drawing.—Ed.]

Tests of Chenoweth Reinforced-Concrete Cross-Ties.

Sir: In the Sept. 30 edition of Engineering News, under the heading "Results of Trials of Steel and Concrete Ties," the following statement is made under the sub-head of "Conclusions." "Experiments with steel ties should be extended and results carefully watched."

The Association does not extend any such recommendations to reinforced-concrete ties, claiming that no suitable ties of this type have been made for heavy traffic. But ought not the Association to aid in the endeavor to find a suitable reinforced-concrete tie?

The report is followed by a lengthy statement on the Chenoweth reinforced-concrete ties used by the Pennsylvania Railroad at Scully, near Pittsburg; 102 cross-ties were delivered and placed in the track Oct. 22, 1906, at a cost of $151.50, which was not by any means an extravagant outlay. At the present date, 41 of these ties are reported as being in good condition, and 46 damaged ties have been removed.

A few additional details which were overlooked by the Committee may be of interest as they argue for the efficiency of the ties, when properly protected, to resist the conditions which exist at Scully.

These ties were the first designed and installed under the Chenoweth system for use on steam railways. There were no possible data for use as a guide. It must be admitted that it would be impossible to produce a tie of this type for constant traffic on a cinder roadbed without trials of some sort. On account of their longer period of development, steel ties seem to have the advantage. A derailed train passed over the Chenoweth ties at Scully in 1907. Four ties were destroyed by the track hands, who drove the clips back into place by a lateral blow with a maul, in order to bend back the screw bolts. These ties would not have been injured if the bolts had been unscrewed in the proper way. A flange of the derailed car wheel scored about one-third of the ties and may have cracked some. At this time (August, 1907), a number of the wooden blocks were found to be cut through, because of defective clips and the rails were pounding directly on the concrete.

On Sept. 17, 1907, another inspection was made and 20 ties were found to be channeled and damaged under the rail, where the blocks had disappeared altogether. Attention was called to this by a report; also that the clips used were not according to the design furnished, as they did not fit the rail and were absolutely useless. It was not expected that the ties would give good results if the concrete were subjected to the direct blow of the rails without the intervention of a wooden block and steel plate.

The result of this test at Scully has been to show that it is absolutely necessary to have a larger bearing for the lower flange when an 86-lb. rail is used. The tie should have been 9 ins. wide instead of 7 ins.; in place of a clip, a screw bolt with a 3-in. head fitting the rail, should be substituted. This would not materially increase the cost of the tie.

That reinforced-concrete ties will stand the wear of railroad use when properly looked after is shown by the result of four years' use of Chenoweth ties in an experimental stretch on the elevated section of the New York Subway at the Dyckman St. station where, out of 100 ties placed in the track in 1905, not one has been taken out, nor do any of them show any sign of deterioration or failure. The traffic of course is not as heavy as at Scully, but it is just as constant and with additional speed. The Scully ties are 7 ins. thick, while the Rapid Transit ties are 5 ins. thick.

Alexander Crawford Chenoweth.

16 Court St., Brooklyn, N. Y., Oct. 7, 1909.

Continuity in Reinforced-Concrete Beams.

Sir: The article by Prof. R. E. Spaulding in your issue of Sept. 30, concerning "Moments in Continuous Reinforced-concrete Beams under Uniform Loading" is interesting, but is believed to be entirely misleading. It may be defended as good practice to ignore tension in the concrete when designing reinforced-concrete members with regard to safe working stresses, but it is believed to be entirely illogical and erroneous not to consider the action of the concrete on the tension side of the neutral plane when dealing with slopes, deflections and stiffness, so long as working stresses are involved. It is obvious that deflections computed after the fashion of your contributor would be far from those actually ascertained from experiment, and that the conclusions as to moments and stresses thus derived must be correspondingly far from being proper ones on which to base any such conclusions as those contained in the last paragraph of the article mentioned.

For instance, in the example given, if it be further assumed that the thickness of the slab is 6 ins., that the centers of the reinforcing rods are 1½ ins. inside the surface, ignoring the error made through figuring both concrete and steel over the areas occupied by the latter, and assuming that the moduli of elasticity of concrete in tension and compression are equal; then instead of a stiffness ratio of 0.51, it is found to be more nearly 0.78; and the moment coefficients at the center and supports are very nearly 1/22 and 1/9 respectively instead of 1/19 and 1/14 as printed. Obviously, the proposed distribution of reinforcement is entirely wrong. More extended mathematical analysis and tests of deflections of actual structures only confirm this conclusion most emphatically.

Yours truly,

E. P. Goodrich.

1 Madison Ave., New York City, Oct. 4, 1909.

Sir: In his article on continuous reinforced-concrete beams [Eng. News, Sept. 30, 1909, p. 344] Mr. Spaulding makes the statement that due to the uncertainty of uniform loading, the non-rigidity of supports and the possible lack of continuity over supports, it is not economical to design beams for a lesser bending moment than $\frac{1}{8} W l$. It would seem that the very nature of the material and the method of construction precludes all possibility of the beam being anything but continuous, in the case of three or more consecutive spans, which is a system of framing usually followed in all classes of work. For, were the tangent to the elastic curve not horizontal at a point over the support, the concrete would have to crack or open up at that point, which is, I believe, a class of failure that never occurs when there is reinforcement over the support. Therefore, as, due to the method of construction, absolute continuity exists across the point of support whether or not we consider it so in designing the beam, why should we not take this fact into consideration in the design, and so proportion the reinforcement that there shall be twice the amount at the top of beam over the support as in the center of span at the bottom of the beam, since the moment at the support is $1/12\ W l$ as against $1/24\ W l$ at the center. This applies of course only to the interior beams of a series of three or more spans.

As far as the effect of unequal loading on adjacent spans is concerned, we have in monolithic concrete construction a condition which is safer than ordinary continuous construction as applied to steel beams. For continuity, as ordinarily understood, does not prevent the virtual lengthening of the more heavily loaded span, by the movement of the maximum in the elastic curve from a point over the support to a point in the adjacent unloaded span. In concrete construction, however, the beam is supported by a girder or column which is at least ten or twelve inches wide, which is built monolithic with the beam it supports, and which, in the case of the column, usually has another column above it, tending still more to maintain the tangent to the elastic curve horizontal for a distance at least equal to the width of the column. The only exception is in the case of roof beams, and here unequal loading of any appreciable amount does not exist.

Regarding the point made that beams designed as continuous and of tee section would not be safe in compression in the lower flange at the support, I agree with Mr. Spaulding. I do not think that this point is often considered in the design of beams. But at the point of greatest compression the section is greatly reinforced by the column or girder which supports the beam, and beyond the support the negative moment decreases as the square of the distance from the support, becoming zero at a point situated out 0.21 of the span. However, I think Mr. Spaulding has assumed a width of flange greatly in excess of that ordinarily used in design. By reducing this flange width to say three times the width of stem for a thin slab, and four times for a thick one, the discrepancy between the compressive strengths of the top and bottom flanges would be reduced, especially if steel were put into this section, which is generally the case. It will be noted, however, that this compressive stress exists in monolithic construction whether the beam be figured as a simple span or as continuous.

H. W. Schlinz.

Chicago, Ill., Oct. 5, 1909.

Sir:. The article on "Moments in Continuous Concrete Beams Under Uniform Loading," published in your issue of Sept. 30, contains a valuable addition to the equipment of the designer of reinforced-concrete structures in the diagram of bending moments in beams with fixed ends, but I do not agree with Mr. Spaulding's conclusions as to the economical distribution of reinforcement. I believe that wherever the rigidity of the support, or the equality of the loads at each side of the support, is sufficient to produce a really fixed end the greatest economy will be secured by heavy reinforcement over the support and less in the center.

The example worked out in the article referred to will illustrate my point effectively. The bending moments in this typical beam are considered with three different ratios of reinforcement over the support, the reinforcement at the center and all other dimensions remaining the same. In each case the strength of the beam over the support determines the load carrying capacity. A comparison of the relative loads which these beams could carry will show at once which is the most economical.

It will be close enough for the present purpose to assume that the moment of resistance of the beam varies in proportion to the percentage of reinforcement. Then the total load carried will be proportional to the percentage of reinforcement divided by the coefficient of moments given in the diagram, Fig. 4. For the first case this will be $\frac{1.6}{.072} = 22.2$; for the second case $\frac{1.8}{.063} = 12.7$; for the third case $\frac{.4}{.053} = 7.55$. Take the carrying capacity of the first beam as 100%; then the second is 57%, and the third 34%. But the total amount of reinforcement in the second beam is about 75% of the first, and in the third beam about 62.5% of the first, so that this last beam, which is said to be more economical than the others, will only carry a little over one-half as much load per pound of steel and about one-third as much load per cubic foot of concrete as the first.

If we now reduce the reinforcement at the *center* to one-half of the original amount, the strength of the beam over the support is still the limit of its capacity, and the load carried will be proportional to $\frac{1.6}{.082} = 19.5$ or 88% of the original beam, with the same amount of

steel as number 2. The capacity per pound of steel would be about 17% greater than the original beam.

The above figures are roughly approximate but will serve the purpose of illustration. The fundamental idea is this: that any attempt to reduce the bending moment at the support by increasing the amount of reinforcement at the center must necessarily reduce the working stress in the steel at the center far below the allowable stress, thus violating the first principle of economic design, which is that every square inch of material shall develop as nearly as possible its full working load.

In a properly designed continuous beam the moment over the support is more than double the moment at the center, and unless the beam is reinforced for the full amount of this negative moment the material will be greatly overstressed at this point before developing the strength of the beam at the center.

Kenneth Hartley.

Kansas City, Mo., Oct. 15, 1909.

Concerning Formulas for Reinforced-Concrete Beams.

Sir: I note the letter from Mr. J. L. Campbell and your reply to same in Engineering News of Sept. 30. Are they not both futile? It is such an easy matter to use a formula that is both simple and correct.

The adoption of a working stress of 12,000 lbs. in steel is not possible, and is unnecessarily conservative, especially as the use of deformed bars is now so general. The use of 600 lbs. as the extreme fiber stress in concrete is also almost universally exceeded. In fact it is probable that $f_s = 16{,}000$, $f_c = 750$ and $n = 15$ is more generally used than any other combination.

Again the use of Mr. Campbell's formula necessitates using less than 1% of steel, and the results of experimental tests upon 1:2:4 concrete beams show conclusively that as high as 1.75% and 2% may be used and the beam not fail in compression. It is, I think, generally recognized that from 1.05% to 1.25% is the best practice.

D. Russell Downey.

3610 Ellis Ave., Chicago, Ill., Oct. 11, 1909.

Suggestions for the Ideal Stadia Rod.

Sir: "About once in so often," almost assuming resemblance to a periodical epidemic, some engineer, seemingly awakening from a sound dream, rises up and devises a combination of hieroglyphics for a Stadia Rod. The writer thinks he has seen nearly a hundred of these. And with a remarkable unanimity, all ignore any consideration of what seem to me fairly important requirements, in a frantic effort to distort figures into graduations, which require a longer or shorter period of study and practice to handle with safety.

As measurements by stadia are becoming more and more popular, a rod which will meet the requirements is becoming more and more of a necessity. Such a rod, it seems to me, should be one which can be used as a leveling rod as well as a stadia rod. The average engineer does not want the burden or expense of two rods nor does he have enough exclusive stadia work to justify the possession of a special rod for that purpose.

It should be graduated so it can be plainly read to hundredths of a foot within a reasonable distance and furnished with a target with vernier reducing the reading to thousandths. The past prevailing idea that stadia measurements could only be approximate is no longer tenable. Stadia measurements made with equal care are more accurate than tape measurements on ordinary country surfaces. Therefore, the rod ought to be more finely graduated than tenths of a foot. And I have yet to learn of any reason why level readings should be any closer than stadia.

It should have a face which is intelligible to any instrumentman or rodman without a waste of time in learning eccentric distortions of figures. What engineer cares to add to his chronic troubles the agony of uncertainty as to whether his employee is bearing in mind that the under side of the line forming the center of the figure three is the one to count from instead of the top side?

It should be so constructed that it can be carried about in public conveyances without being a nuisance or a terror to other travelers than its owner. The day has already come when the engineer resorts largely to steam or electric cars in getting to or from his work and there is little likelihood that the steam, street or interurban cars of the future or even buggies will be constructed to accommodate a leveling rod which cannot be closed shorter than seven feet.

It should have a face as wide as possible and still be rigid in a ten-mile wind.

It should be as light as possible and still be rigid. It should be as long as possible and still be rigid. A nice adjustment of material and construction will be required to obtain the greatest possible width, length, and rigidity with the least weight.

It should be furnished with two especially large targets, one to clamp at the top and the other to be set to place within reach of the rodman, the largest possible targets which can be carried about without too great inconvenience.

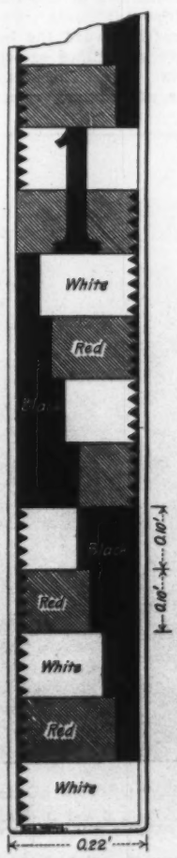
Its face should as distinctly show the graduation marks as the figures and the one should not be a part of the other.

That such a rod is possible there can be no question. But when the old time leveling rods, with which we are all familiar, were devised, stadia surveys were hardly known and practically never practiced. Changes in conditions have always brought about implements to meet them and the proper stadia rod will not be an exception.

"Suggester."

Chicago, Ill., Oct. 11, 1909.

Sir: The stadia rod design presented by J. C. L. Fish in the Oct. 7 number of Engineering News is a good one of its kind, but I have been so long emancipated from numeral rods for this class of work that I feel like urging my fellow engineers to try my plan. A simple rod divided into either 6-in. or 12-in. alternate red and white sections is the easiest thing in the rod line to read. There is no doubt as to where the reading begins, and subtracting one numeral from another is eliminated. The lower stadia wire is fixed upon a division line that will throw the upper wire upon a division subdivided into tenths, and the reading is thus reduced to a simple enumeration of the intercepted spaces. This can be done rapidly and with less danger of error than in reading any other form of rod that I have ever used. Personally, I prefer a rod divided to five-tenth sections, using half the stadia intercept. This saves the inconvenience of carrying a long unwieldy rod and in windy weather the short rod shows its marked superiority in increased steadiness. The rod I now use is 5 ft. in length, with a screw joint in the middle and a hardened steel point 6 ins. in length. The top division is divided into ten spaces or bands of 1/20-ft. each, painted alternately red and white except the fifth one which, for convenience in reading, is painted black. The rod is ¾-in. in diameter, is made of white ash, and weighs only 19 oz. Many severe tests of this rod under trying conditions show that it is up to anything in reason as to durability. With it I can read distances as accurately as skilled chainmen can measure them, and far more accurately than the work is done by the help ordinarily available. My surveys balance in a way that they never did in the old days when I used a chain. This rod can just as well be made 6 or 8 ft. in length, but in the hilly region where I work sights of 1,000 ft. are rare. The screw joint is invaluable for shortening the rod in sighting through difficult places in the woods. I can read this rod at greater distances and with more accuracy than any numerated rod that I have yet found. Try it and be convinced.



"Florida" Stadia Rod.—Wm. MacDonald.

E. Newton Millen.

Newton, N. J., Oct. 12, 1909.

Sir: With reference to the design for a stadia rod submitted by Prof. J. C. L. Fish, of Leland Stanford University, published by you Oct. 7, I would say that while it has many excellent features, to my mind it does not come up to the "Florida Rod" which I introduced in the topographic survey of the Borough of Richmond, New York City.

Prof. Fish's rod is eminently adapted to long sighting, as the figures are half a foot high, but the range of the rod is only 1,200 ft., with an intercept of one per hundred. This is twice as long as you can do effective stadia sighting, as the higher the power of the lens the greater the distortion, and likewise the greater the intercept the greater the distortion. To get effective stadia work you require a power not exceeding 20 dis. and sights of 500 to 600 ft.

The Florida rod is only 0.22 ft. wide as against the Fish rod width of 0.35 ft. This makes a very heavy rod for a man to haul around all day. The Florida is usually made 10 ft. as against 12 ft. for the Fish rod. The only figures are the foot marks. Tenths are indicated by alternate white and red blocks on a black ground; they are stepped for the first half foot one way and for the upper half foot in the opposite direction. The hundredths are shown by serrated edges as per sketch below.

It will be noted that from point to point of the teeth is 0.02 ft., and each 0.01 ft. is indicated from point to bottom of teeth. If in close reading, say for instance in measuring a stadia circuit, even closer readings are desired, they can be obtained as the diagonal side of the tooth can be subdivided by the eye. If only approximate readings are looked for, the white and black spaces can be subdivided by the eye.

I also designed a target with a horizontal slit for laying off instrument height, which makes this rod the all-round best rod for the purpose.

Wm. MacDonald,

Ass.t. Engineer Construction, Borough of Richmond.

New York City, Oct. 14, 1909.

A Short Cut to the Rational Purchase of Coal.

Sir: I have read with much interest your article in Engineering News of Sept. 9 on the purchase of coal under specifications, for it shows very conclusively the value of paying for heat units instead of heat units plus ash.

Ordinarily this method of purchase is used only when large quantities of coal are required on account of the expense of making the determination of the calorific value of the coal. A determination of the ash content of a coal is often enough to enable one to judge of its heating value and since the analysis for ash only is not expensive it can be applied advantageously to the purchase of comparatively small quantities of coal.

The Charles River Basin Commission of Massachusetts, which is improving the Charles River at Boston by the construction of a dam, lock and embankment (see Engineering News, 1905 Jan.-June, p. 31; 1906, Jan.-June, pp. 243 and 287; 1908, July-Dec., p. 27), requires a few hundred tons of anthracite coal yearly for its heating plant and has adopted a method of comparing bids and of payment which may be of interest. It is best explained by the following extract from the specifications of one of its coal contracts:

The bidder must state with his quotation what percentage of ash the coal which he proposes to furnish will contain and payment will be made on the basis of the price named in the proposal, corrected for variations of ash and also corrected for sulphur in excess of 1%, both as shown by chemical analysis. These corrections will be made as follows:

For an increase up to 2% in the ash contained above or below the standard established by the contractor no correction will be made in the price. When the variation exceeds 2% above or below the standard, corrections in the price will be made as follows: for variations from the standard percentage of ash exceeding 2 and less than 2.5 above and below, the deduction or addition of 15 cts. per ton, respectively, will be made; for each additional ½ of 1% or fraction thereof, in excess of 2.5%, 3 cts. per ton more will be deducted or added, respectively. This deduction will be made up to a maximum ash of 14%. For each additional ½ of 1% or fraction thereof in excess of 14%, 6 cts. per ton more will be deducted.

When the sulphur exceeds 1% further correction in the price will be made as follows: for each one hundredth of 1% in excess of 1% the sum of ½-ct. per ton will be deducted.

The Commission reserves the right to reject any coal which contains ash in excess of 15% or sulphur in excess of 1.75%. In case of such rejection the contractor shall, at his own expense, remove the coal within ten days after being notified so to do.

Proposals shall be made on the basis of tons of 2,000 lbs. Sworn statements of the weights delivered shall be sent to the Commission within two days after each delivery.

Samples of the coal will be taken at the time of delivery, and the contractor may, if he desires, have a representative present to see the samples taken and sealed. The sampling will be done as follows: not less than 100 lbs. will be taken in small lots from various parts of the delivery; this will be mixed and a sample weighing about 5 lbs. will be taken from it, which will be analyzed. A copy of the result of the analysis will be mailed to the contractor as soon as it is received. Coal containing an excessive amount of dust and fine coal will not be accepted.

Yours truly, Edward C. Sherman,

Assoc. M. Am. Soc. C. E.

Culebra, Canal Zone, Panama, Oct. 4, 1909.

Notes and Queries.

Our attention has been called to the fact that in the reprint of Mr. S. Bent Russell's paper on "The Cost of Clearing Water in Settling Basins," published in our issue of Oct. 14, 1909, p. 395, the following errors were made: In the last line of the first paragraph in the third column on page 396, "9%" should read "8%"; also, in Table II., the commas in the last three columns of the table should be decimal points, making the final average total cost of coal per million gals. $5.898 instead of $5,898.

In connection with the article on "Temperature Stresses in the Members of Steel-Structures," in our issue of Oct. 21, attention is called to the steel truss swing bridge at Bristol, England, described in our issue of Aug. 19, 1909. As the result of a warm sun on a morning following a frosty night, with the sun striking one side of the bridge while the other was in the shade, the structure warped horizontally to such an extent as to jam the tail lock so that the bridge could not be opened until the warming up of the other truss restored the structure to its normal condition (p. 189).

The Collapse of a Wrought-Iron Stand-Pipe at White Plains, N. Y.

At 6.30 p. m., Oct. 20, 1909, a calm, fair evening, the upper part of a 180,000-gal. wrought-iron water tank used in the water service of the village of White Plains, N. Y., collapsed without warning, and the released water and falling plates completely destroyed the adjoining valve and storehouse, somewhat damaged a nearby barn and flooded the cellars of some adjacent dwellings. Fortunately no one was around at the time of the collapse, so there were no casualties. Luckily, also, the general flow of the water was away from the residences in the immediate vicinity so that it was most all carried away to the fields without serious damage. The tank was full at the time, but the water ran off only down to a level 24 ft. from the ground, below which the pipe remained intact.

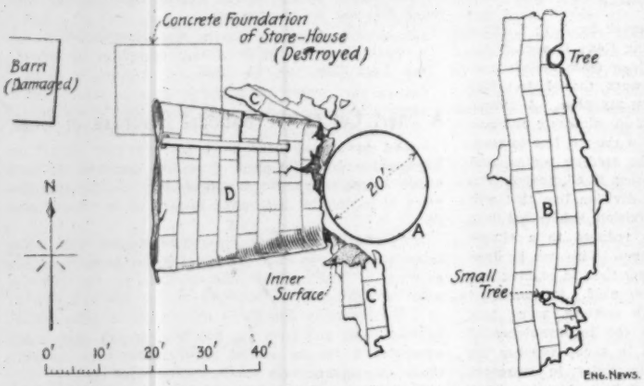


FIG. 1. LAYOUT OF THE STAND-PIPE AT WHITE PLAINS, N. Y. AFTER THE FAILURE OF OCT. 20, 1909.

The White Plains stand-pipe, an auxiliary to the pumping system of the local water-works, was built in 1886 for the then privately-owned water company. In 1891 the system was taken over by the village and is now operated under the direction of a board of water commissioners. The stand-pipe was of 180,000 gal. capacity, 80 ft. high and 20 ft. diameter. It was made up of 20 circumferential rings of wrought-iron plate, each 4 ft. deep and consisting of seven plates, lap-jointed with a double line of rivets at vertical seams of the bottom 15 rings and a single line elsewhere. Measurements on the fallen tank would indicate an original metal thickness of from 3/16 to 3/8-in.; no plans of the structure are available. The bottom is of the usual bottom plate and side angle construction, footing on a masonry foundation. Seven anchor bolts, one from each of the plates on the second row, held the tank against tipping.

The accompanying views and sketch show the condition of the pipe the day after the collapse. Part "A," the lower six rings of the pipe, is still standing, apparently plumb and in its original location. Part "B," four rings deep, is lying about 20 ft. east of the stand-pipe, stretched its full circumference inside face down on the ground. Part "D," the upper eight rings, is lying with its lower end just west of the old location, the cylinder still intact, but smashed flat by the impact with the ground. Attached to the lower, now the east, end of "D," is part "C," two rings. This section has been ripped wide open, in a manner similar to the next lower "B," but a portion of its length did not tear away from "D," and is now bent up in a twisted plate inside of that flattened cylinder. Except for a very small part of "C," bent back in falling, none of the inside face of the tank is exposed.

In falling the upper section "D" broke the anchor bolts on the west side of the tank. The other bolts are all intact, except one on the east side, where the casting at the upper end of the bolt has been cracked clear through its projecting lug. All of the bolts show evidences of slipping both in the loosening up the ground around their bottoms and in the position of their top nuts which are from 3 to 5 ins. above their original seats on the casting. The portion of the tank still standing, in spite of this marked movement shown by the present condition of the anchor bolts, seems to be back in its original position on its masonry base. The waterproofing there, however, is cracked and crumbly so that it can be pulled out.

The breaks, wherever the impact of falling has not destroyed all evidence, are about evenly divided between rivet lines and plate. In a number of places, particularly at both edges of the northwest and southwest corners of "B," the break is through a line of rivets, so that one plate is left with the saw-tooth edges of a line broken through rivet holes and its companion-piece left with the rivets and the loose end of the first plate. In no case was a rivet sheared through plate discovered, nor were any rivets pulled out by direct tension.

The metal is in an extensive state of corrosion. The whole interior surface, where it could be seen, is one mass of flaky rust, of such age that the lightest touch of the hand to an overhead plate will bring down showers of the flakes. In addition to this general rusty condition there are long grooves rusted out from the inner surface, in a manner exactly similar to that described and illustrated in the article on the failure of the stand-pipe at Waterloo, N. Y., in our issue of June 25, 1908, p. 681. These grooves extend in vertical rows the entire height of each section of the pipe, about in line with and of the same spacing as the rows of horizontal rivets. They are deeper and more extensive toward the bottom of the tank, being there sometimes as wide as 1 in. and at least 1/16-in. deep. The section of the metal at the points of ordinary rusting must be reduced by 10% from its original thickness and at these grooves the reduction probably is as high as 30%. The inside heads of the rivets are much diminished in section, being reduced in some cases to a cone with a base but slightly larger than the body of the rivet.

The character of the metal is well indicated by the piece "B," which was thrown some 20 ft. east of the tank. This sheet of metal, 63 ft. long, about 15 ft. wide, and from 3/16 to 5/16-in. thick, was driven from a height of 25 ft. against two trees, one a dead hard-wood about 24 ins. in diameter and the other a live tree, some 8 ins. in diameter, and in both places was sheared straight through like so much tin. At these breaks the metal is twisted and cracked as though it had come in contact with an iron pole, instead of a soft and easily breakable wood.

The metal itself, a wrought iron, is highly laminated at each of the breaks; the fractured end is in small stepped sheets, resembling the fracture of a piece of slate.

As no one saw the collapse of the pipe and as there is no knowledge of any particular weakness previous to the failure, the only evidence for causes must be sought in the present condition and position of the various parts on the ground. From an inspection of these parts it seems most probable that the initial failure occurred on a vertical seam between the seventh and eleventh ring from the bottom, on the west side of the stand-pipe. This section, where evidence points to initial failure, is now the north and south ends of the long piece "B," lying to the east of the stand-pipe.

According to this theory, when the first leak started, the outrushing water ripped a vertical opening for about four rings and then the tear started on horizontal rivet lines both above and below, tearing out the four-ring strip which has been thrown to "B" on the east. The upper section "D" then dropped out toward the west, where its support was first removed. Before it fell, however, the vertical rip had started above the four rings of section "B," and had torn off for a portion of the circumference the two rings of section "C" which is now lying, stretched out for nearly its full circumference, mixed up with and attached at its east side to section "D." It will also be noticed that at just about the middle of section "B," on both upper and lower edges, there is a projecting piece of metal which has torn out of the adjoining plates. Evidently the strip started to tear out along rivet lines and so continued to a point directly opposite the break, where the weight of the fast falling section and the rush of water was so great as to bend the section over and rip out these small patches of metal.

As shown on Fig. 1, the west (originally the upper) edge of section "B" is on the seam with

FIG. 2. VIEW OF THE COLLAPSED STAND-PIPE, WHITE PLAINS.

(Taken looking northwest. Parts C and D (Fig. 1) in left foreground. Note V-shape tear at top of standing portion on extreme right and compare with similar shaped projection on part "B," Fig. 1.)

the exception of the small projection near the middle. Furthermore, the break at the two corners of this edge is through the rivet lines for a considerable distance in both directions. This edge is also the line of changed section where the plate reduces from an original 5/16 to ¼-in. These facts would seem to indicate that here was the initial fracture, though there is no evidence along this line of a corrosion any greater than anywhere else. The very irregular edge in the east side of section "B" is due to the interference of the two trees, as much as to the original break.

No previous leaks that had not been patched are reported, but about a year ago a patch was placed in the upper eight rings. This patch is now visible in the section "D." It is understood that the interior of the pipe never has been painted, and the present condition would seem to verify the report. However, the water commissioners claim that when the above-mentioned patch was put on, it was reported by a competent inspector that the interior was in a very fair state of preservation and that no danger need be apprehended. In spite of this claim, there seems to be no doubt that the failure occurred from the ordinary full-tank water pressure on plates and seams greatly weakened by corrosion.

We wish to thank Mr. P. L. Braunworth, C. E., of White Plains, for his assistance in our inspection of the stand-pipe and in gathering data.

FIG. 3. VIEW OF WHITE PLAINS STAND-PIPE.

(Taken looking southeast. Part D in right foreground. Part B on ground by group of men at left.)

ILLUMINATED STEAM-JET "FIREWORKS" were exhibited in New York City during the two weeks of the Hudson-Fulton celebration. The effects were produced by throwing the rays of search-lights upon clouds of steam. Very beautiful results were obtained by means of transparent colored screens held in front of the search-lights. The pipes from which the steam issued were arranged so as to give steam clouds of a variety of shapes as desired, and more or less distinct "set-pieces," or definite outlines, were produced. For example, the smoke-stack of a representation of the "Clermont" (the most elaborate set-piece attempted) was made by two vertical pipes separated by a space of between one and two feet. Each pipe was perforated on the side toward the other pipe by a row of closely spaced holes. Steam jets from these perforations formed a cloud or curtain of steam with a shape approximating that outlined by the pipes. Steam from a cross-pipe at the top, perforated on its upper side supplied an appearance of smoke issuing from the stack.

The illumination of the steam was effected by two batteries of projectors mounted on a platform at a distance of about 200 ft. Each battery consisted of one 24-in. and nine 30-in. projectors, and each projector was equipped with twelve color screens. The screens were made of thin sheets of a special gelatin stretched in wooden frames and reinforced by poultry netting on one side and straight copper wires, crossing each other at right angles and spaced about 8 ins. apart, on the other side. Six of the screens for each projector were mounted on a frame at the front so arranged that any one screen could be swung into place in front of the light as desired. The other six screens were arranged to be held in position by hand. One man was required to operate each projector, a lieutenant was in charge of each battery of ten and a captain directed the operation of the whole equipment, including the steam piping.

The scintillator (the name applied to the entire apparatus) was installed for the two weeks of the celebration on Riverside Drive on the viaduct between 153d and 155th Sts. The steam used was supplied by two locomotives stationed on a New York Central siding beneath the viaduct. Current for the projectors was supplied from the mains of the New York Edison Co.

Step-down transformers took current from the mains (two-phase, 60-cycle) at 2,200 volts and supplied it at 90 volts to rotary converters. The converters supplied direct current for the projectors at 117 volts, and the output of the converter installation is about 175 KW. The projectors were of the type made by the General Electric Co. and used 75 amperes of current each, at 80 volts across the arc.

In the operation of the rotary converter, a method of establishing synchronism was employed which is rarely used outside of laboratory work. Power was taken from a turbo-generator, reserved during the evenings for this purpose, at the Waterside station at 39th St. In starting, the turbo-generator was operated with field fully excited and the rotary converter was subjected to full current with its field open, being run as an induction motor. When the converter had attained maximum speed, the 39th St. station was notified, steam was shut off from the turbine and the field of the converter closed. The converter, continuing to run by the inertia of its parts, acted as a generator and pulled the turbine unit into synchronism. Steam was then again admitted to the turbine and this began to drive the converter at increasing speed with synchronism established.

The scintillator had its inception some three years ago in the attempts to illuminate Niagara Falls. A line of large arc projectors, in fact the same ones brought to New York for this celebration, was arranged to flood the falls, and its spray and mist, with various and varying colored lights. Possibly the effect on the clouds of mist and spray suggested the use of steam. The use of steam was made, though to a lesser extent than in New York City, at Nahant, Mass., a little later. The whole development has been the invention of Mr. W. D'A. Ryan, Assoc. Am. Inst. E. E., of Schenectady, N. Y.

PRODUCTION OF CRUDE PETROLEUM.—The Bureau of Statistics, Department of Commerce and Labor, has compiled the following table of the world's production of crude petroleum in 1904 and 1908 and of the proportion of the whole produced by each country:

	1904.		1908.	
	Millions of bbls.*	Per cent.	Millions of bbls.*	Per cent.
United States	117.1	53.4	179.6	63.1
Russia	78.5	35.8	62.2	21.9
Sumatra, Java and Borneo	7.7	3.5	8.8	3.1
Galicia	5.9	2.7	12.6	4.4
Roumania	3.6	1.6	8.3	2.9
India	3.4	1.5	5.0	1.8
Japan	1.4	.7	2.1	.7
Mexico	....	....	3.5	1.2
All other	1.7	.8	2.5	.9
Total	219.3	100.0	284.6	100.0

*Barrels of 42 gals.

In 1904 the value of exported mineral oils was 79.1 millions of dollars. In 1908 it was 104.1 millions. Thus it appears that while the increase in production was 53.4% of the 1904 figure, the increase in value of exportations was only 31.7% of the value for that year.

THE COST OF SEWAGE TREATMENT at the Davyhulme works of the city of Manchester, England, during the year ending March 31, 1909, was £2 4s. 6d. per 1,000,000 Imp. gals., or about $9 per 1,000,000 U. S. gals. The treatment employed included sedimentation and septic treatment and passage through contact beds, with the application of excessive storm flow to special beds and of a small portion of the effluent of the contact beds to second contact beds. The cost figure given does not include interest or sinking fund. The cost per 1,000,000 U. S. gals. was subdivided as follows: Sludge disposal, $2.56; filtration, $4.37; general expenses, $1.70; coal, 40 cts. The average cost per capita for the year ending March 31 was 12.4d., or about 25 cts., which compared with 9.3d., or some 18 cts., for the five years ending March 31, 1909. It is interesting to note that the cost of filtering sewage was divided between maintenance and renewals in a ratio of about 5 to 18. The total quantity of sewage received at the works during the year was 16,419,493,200 U. S. gals., of which 15,133,308,200 gals., or 92.2%, was filtered. Further information regarding these works is given in the report of the Manchester Rivers Department for 1908-9.

FIG. 4. VIEW OF WHITE PLAINS STAND-PIPE.

(Taken looking west. Part "B" in foreground, the original lower portion is the edge nearest the eye.)

Handling Stamp Mill Tailings by Belt Conveyors.

The economical disposal of the crushed rock tailings from the stamp mills is one of the problems of the Michigan copper district, as there is an enormous amount of this waste material to be removed and disposed of. As large quantities of water are required to carry this material away from the stamps (from 20 to 30 tons of water for each ton of tailings), the mills are usually located near Lake Superior or some local lake, and the tailings are discharged into the lake. It has been the general practice to use the water from the stamps to carry the tailings in flumes or launders all the way from the mill to the point of discharge. To handle such heavy material, these flumes require a grade of about ¼-in. per ft. and where the mill site has only a small elevation above the lake level the upper end of the flume will be at a higher elevation than the mill. This involves raising the tailings and water to a considerable height for delivery into the upper end of the inclined flume.

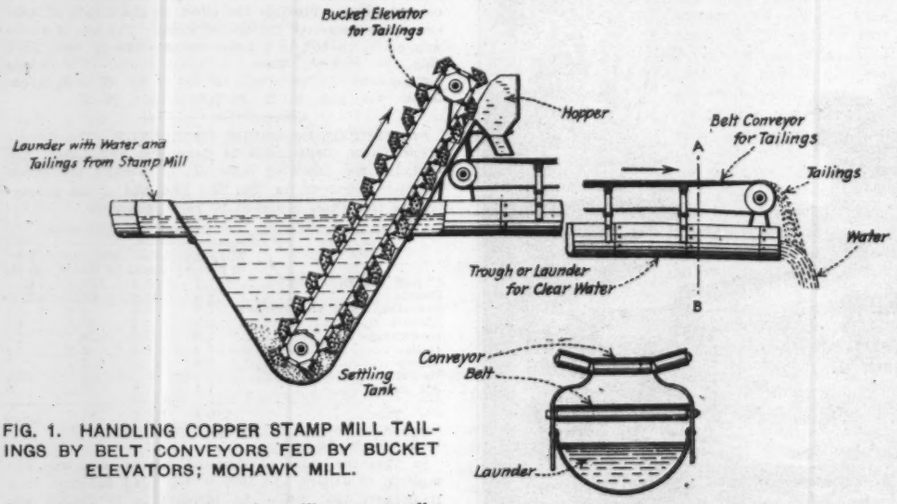


FIG. 1. HANDLING COPPER STAMP MILL TAILINGS BY BELT CONVEYORS FED BY BUCKET ELEVATORS; MOHAWK MILL.

One method of raising the tailings is by huge sand wheels, having the rim fitted with buckets which take the material from a pit and deliver it at the top of the wheel into a flume. Some of these wheels are 54 ft. and 65 ft. diameter, and were described in our issue of Nov. 21, 1901. Each 65-ft. wheel is driven from a 750-HP. motor by a pinion meshing with a gear on the face of the wheel. This method is cumbersome and expensive, and requires a large expenditure of power merely to handle waste material and the water necessary to carry this material through the flumes. Pumping has been tried, but the material cannot be handled economically in this way, owing to its hard and sharp character, while this method also involves the handling of large quantities of water which might otherwise be allowed to flow away.

A marked economy in the removal of the tailings has been effected by the introduction of a system which provides for the separation of the tailings from the water, carrying the former only by power and allowing the waste water to flow away by gravity, but returning the tailings to the water at the point of discharge. In this way only a very slight grade is required, and there is consequently a saving in the total lift. Thus with the same elevation at the mill, the elevation of the point of discharge will be considerably higher for the light-grade separate system than for the steep-grade combined system, so that there is a greater height available for the waste bank. The cost of machinery and of operation are reduced considerably by the separate system, as power is required only for handling the relatively small amount of solid matter.

This system of disposal for the tailings was first devised and patented by Mr. J. F. Jackson, Assoc. M. Am. Soc. C. E., of Houghton, Mich. (Resident Engineer for the Wisconsin Bridge & Iron Co.). The first plant on this system was built for the Mohawk Mining Co.'s stamp mill at Gay, Mich. This mill is about 800 ft. from and 35 ft. above Lake Superior, into which the combined flow of water and tailings had been delivered by gravity until the waste bank had reached the level of the discharge end of the flume. It was necessary then either to raise the entire flume, and install machinery to elevate the tailings and waste water at the mill for discharge into the upper end of the flume, or else to introduce some new method. The Jackson system was adopted as a solution of the difficulties.

With this system, shown in Fig. 1, the stream of waste water and tailings coming from the mill is discharged into one side of a settling tank of V-section. On the opposite side of this tank or pit is an inclined elevating conveyor, having an endless chain of perforated buckets. The buckets take the tailings from the bottom of the tank and discharge them at the head of the elevator upon a traveling belt. The water from the tank overflows into a flume under the belt conveyor, requiring only a slight grade. At the end of the conveyor, the tailings are dropped into the flume, which has then a steeper grade to the point of discharge into the lake.

The Mohawk plant handles about 2,000 tons of tailings per day. There are four settling tanks, only two of which are in use at one time, the other two being for reserve or alternative use. Each tank is about 10 ft. long, 5 ft. wide and 7 ft. deep, and has a bucket elevator (with buckets 20 ins. wide) running at a speed of 30 ft. per min. and driven by an electric motor at 2½ HP. The elevators have an angle of about 60° and a vertical lift of about 10 ft. The buckets discharge the tailings into a large hopper, from which they are delivered by a spout onto a conveyor belt carried by troughing rollers, and running in an enclosed shed or gallery.

The belt conveyor has an effective length of 700 ft., with a fall of about 15 ins. in that distance. It travels at a speed of 338 ft. per min., and is driven by an electric motor of 8 HP. This conveyor was built by the Robins Conveying Belt Co., of New York, and its construction, with the arrangement of the troughing rollers and the end pulleys is shown in Fig. 2. The clear water overflowing from the settling tanks, which amounts to about 14,000,000 gals. per day, flows by gravity in a 4-ft. semi-circular steel flume directly under the conveyor and having a fall of about 3 or 4 ins. per 100 ft.

It is to be noted that by this system only one ton of crushed rock tailings is handled mechanically or by power, as against one ton of tailings and 30 tons of water under the old system. It is peculiar also, in that the tailings are taken from the water at one point, carried along on a conveyor just above the stream of clear water, and then dumped back into the water at a distance of 700 ft. with a gain in elevation of about 16 ft. above the former level of the discharge end of the flume. That is to say, with the same elevation at the mill end, the discharge end of the separate system is 16 ft. above that of the combined system, owing to the much steeper grade required by the latter.

In applying this system to the Wolverine mill, which is adjacent to the Mohawk mill, it was modified and simplified in an important manner by eliminating the bucket elevators, and using gravity separators with the conveyor belt depressed so as to pass beneath them. The gravity separator was designed by Mr. Willard J. Smith, Assistant Superintendent of the Wolverine Copper Mining Co. (Gay, Mich.), and the arrangement is shown in Figs. 3 and 4.

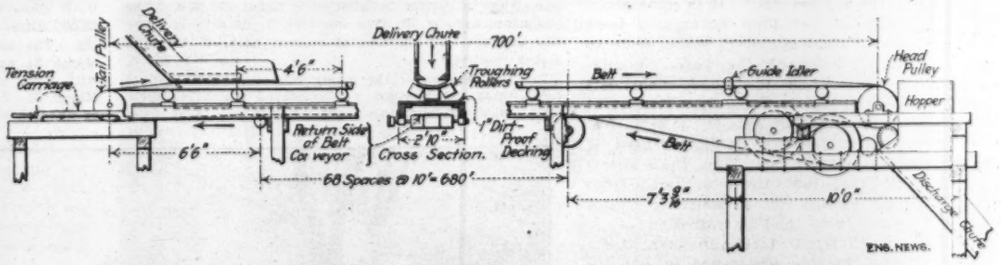


FIG. 2. BELT CONVEYOR FOR HANDLING COPPER STAMP MILL TAILINGS.

The stream of water and tailings from the mill is discharged into a double settling tank, the first compartment of which is fitted with a baffle plate which checks the current and tends to throw the solid matter to the bottom. Here the coarse material is deposited, and the water rising on the other side of the dividing partition overflows into a second smaller tank where the fine sand and slimes are deposited. The clear water then overflows into a flume leading to the lake. In the bottom of each tank are spouts (fitted with sliding gates) delivering the solid material into a screen box having inclined perforated screen plates. This screening removes much of the water, and the screened material (containing about 15% of water) is then fed through inclined

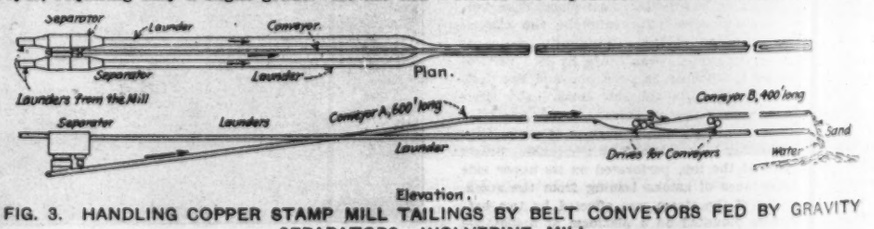


FIG. 3. HANDLING COPPER STAMP MILL TAILINGS BY BELT CONVEYORS FED BY GRAVITY SEPARATORS; WOLVERINE MILL.

spouts or nozzles upon the conveyor belt. The belt rises at a slope of 5% until it is above the level of the flume carrying the water, over which it extends (on an incline of only 1-16-in. per foot) to the point of discharge at the lake.

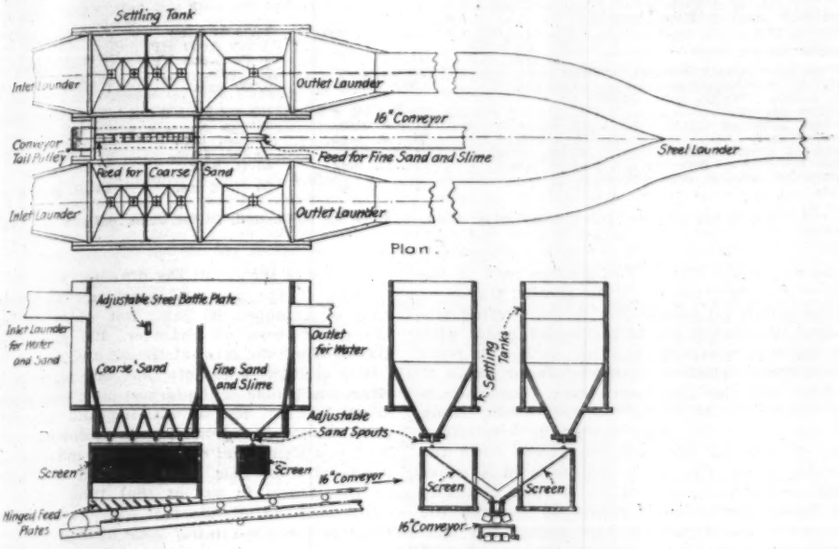


FIG. 4. DETAILS OF GRAVITY SEPARATORS FOR COPPER STAMP MILL TAILINGS.

There are two flumes from the mill, and two sets of settling tanks and screen boxes placed side by side; the tanks have a lateral discharge to a single conveyor belt which runs between them. The clear water flumes leading from the tanks unite in one beyond the point where the inclined conveyor belt passes between them. Only one set of tanks is in regular use, the other set being held in reserve. The clear water discharge flume is a semi-circular steel trough 30 ins. wide. The conveyor receives first the coarser material, and the finer material is delivered upon this, as the latter has a tendency to cling or adhere if it comes in contact with the belt. The openings of the spouts from the settling tanks are regulated according to the amount of tailings coming from the mill.

The Wolverine plant handles daily about 1,000 tons of tailings and 7,000,000 gals. of water. The length of the conveyor is 600 ft., but a second one has been installed as an extension ready for use when it becomes necessary to deliver the material at a greater distance. This additional conveyor (which will be fed by the first one) is 400 ft. long, but may be extended to 600 ft., making a total run of 1,200 ft. from the settling tanks. They are both driven by sprocket chains from a shaft geared to an electric motor of 15 HP. These conveyors were designed and built by Mr. C. Kemble Baldwin, Chief Engineer of the Robins New Conveyor Co., of Chicago. The builders state that when the 600-ft. conveyor is handling 40 tons of material per hour, carrying it at a speed of 224 ft. per min. and elevating it about 17 ft., the power consumption is 7.7 HP. When the belt is running empty, it requires about 5.8 HP.

The design of the conveyors and durability of the conveyor belts are important factors in the successful operation of these plants. At the Mohawk plant, a 20-in. rubber belt was used. We are informed that the first belt was destroyed by the edges becoming worn so as to expose the duck, which then absorbed water, causing the rubber to lose its hold on the duck and thus lead to a separation of the plies. On the other hand it is to be noted that rubber belts have been used extensively and successfully for handling tailings, dredgings and other wet material. The belt now in use at the Wolverine plant is a 16-in. four-ply balata belt. The balata (which takes the place of rubber) is a vegetable gum and is applied to the duck in a liquid state so that the fabric becomes thoroughly saturated and the belt is entirely waterproof. Three 32-in. six-ply balata belts have been in use for three years for handling the output from a government dredge on the Fox River, in Wisconsin. At one time a boulder lodged against an idler pulley in such a manner that the belt rubbed against both the boulder and the pulley, but though it was worn down to three plies on one side it showed no indication of separation of the plies.

A Novel Leveling Apparatus for Use in a Sewer.

By G. S. COLEMAN,* Assoc. M. Inst. C. E.

Some time back the present writer was instructed to obtain the invert levels of a certain length of sewer on which there was, at that time, every probability of a lawsuit. This sewer turned out on inspection to be of brick and of the standard "egg-shape" section, 30 ins. high by 20 ins. wide. It was also found to be continually running about 15 ins. deep and to be in a very shaky condition. Strict instructions were therefore issued that no one was to attempt to enter the sewer beyond going down the manholes, but the levels were required if possible every 5 ft., as the contention of one of the opposing parties was that the gradients were largely composed of "back falls."

The sewer was found to be straight between the manholes which were from 300 to 400 ft. apart. The works have been constructed some 30 years and in several lengths there was a deposit of about 6 ins. of fine gravel or ballast. In other lengths where the current was too swift to allow the gravel to remain was found a large number of brickbats, which had apparently been there since the sewer was constructed. After a good deal of thought the method of obtaining levels now to be described was used, and apparently with the utmost success. As the writer has never seen such a problem treated of previously, he ventures to bring it before the notice of his brother engineers.

Fig. 1 represents a plan and Fig. 2 a side elevation of the apparatus which carried the level-rod. The sketch shows the actual machine which probably could be easily improved upon, but the writer was so busy with other work before he went onto this particular job that he had to leave the details to the head carpenter.

A is a hexagonal framework of short pitch pine screwed firmly together. In the underside of this frame is fixed a stiff board *B* with a square hole in the exact center of the frame. *A* is connected to a powerful steel "skate" *D* by means of inclined pieces. These inclined pieces are further stiffened by cross bars *G*, which also serve to carry a hook to which is attached the rope for towing the whole apparatus in either direction. Longitudinal bars also brace the pairs of inclined bars together and carry another cross piece through which the special level rod staff passes. It was found afterward necessary to fit the shoe *E* to the skate. This shoe was in two portions, one on either side of the skate, and ensured that the staff was down at its proper level in the invert of the sewer, allowing for the thickness of the metal of *E*. It also further prevented the post of the staff from being dragged backwards by any obstacle which the skate had pushed on one side and so shoving the staff out of the perpendicular.

K K are two wooden bases into which were passed two powerful acetylene lamps of the size usually fitted to the rear of motor-cars. These lamps were turned so as to throw a powerful light onto the level rod. The only remaining joint of the apparatus left to be described is the rod itself. This was probably unique and created a good deal of amusement amongst the writer's colleagues. It, however, served its purpose admirably after one or two mishaps. It was in two parts and was telescopic. Instead of the upper portion being drawn out it was forced out by a powerful spring inside the lower half and was prevented from jamming against the crown of the sewer by having an ordinary swivel chair-caster fitted to it. Similar casters, shown at the sides of the apparatus, were screwed to flat springs and served to support the whole frame upright in the sewer. The lower portion of the staff was made solid and had to be afterwards sheathed with metal to protect it from the heavy usage it experienced. It was made with a deep fork, which allowed it to ride on the skate *D* protected by the shoe *E*, as explained above. On both sides of the staff were glued the ordinary divisions, showing feet and decimals of the foot, the staff being graduated from the bottom of the shoe *E* or what is the same thing, the underside of the skate *D*.

The way in which the levels were taken was as follows: As the manholes were merely shafts

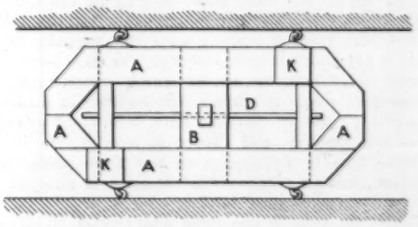


Fig. 1. Plan.

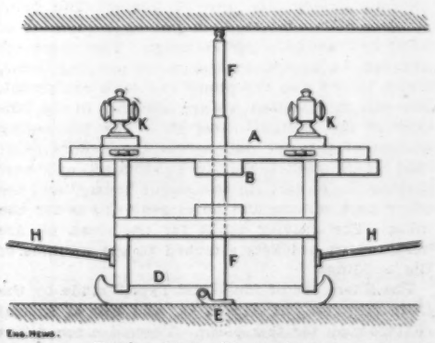


Fig. 2. Side Elevation.

Figs. 1 and 2. Plan and Elevation of a Device for Holding a Level Rod in an Inaccessible Sewer.

formed by continuing the brickwork upwards from the opening of the crown of the sewer, it is obvious that there was not enough room to set up the instrument. The instrument-man fixed the level to a board wedged across the sewer and arrayed himself in oilskins, practically down in the sewage so as to be in a position to read the lowest sights. In two cases this turned out to

*28 Hesketh Ave., Didsbury, England.

mean that the water rose to within 3 ins. of the line of collination. Fortunately the spider hairs never snapped.

In reading, two sights have usually to be booked, first the reading on the upper staff as given by the collination, and secondly the reading on the upper staff where it was cut by the lower hair. The readings were shouted up the shaft to another assistant on the surface, who booked them and also recorded chainage and collination level. To obtain this latter the method used was similar to the usual operation of chaining. The pulling ropes were fitted with tabs at every 5 ft. from the center, and men were stationed at the next manholes higher up and lower down who pulled when shouted to. The rope passed under the instrument and through the legs of the observer, who stopped them when he found that the apparatus had moved forward another 5 ft.

An objection that will probably be raised will be the error introduced by increasing lengths of the sights. This was foreseen, and to prevent it as far as possible the instrument was always transferred to the next manhole wherein half the distance between the shafts had been covered.

As a final word to anyone who may essay to use a similar device the writer would add that, in pulling the apparatus, it was found necessary to move it with a motion alternately forward and backward. This enabled the skate to saw its way onto the true invert, and always enabled it to push aside any obstacle in its way.

Oil Filtering Plant at the Rolling Mills of the Indiana Steel Co.

The rail and billet rolling mills of the Indiana Steel Co.'s new works at Gary, Ind., are operated by very large and powerful electric motors (as described in our issue of Aug. 12), and the bearings of these motors require a very liberal supply of oil, owing to the heavy service imposed upon the machines. The flush system of lubrication is used, in which there is a continual flow of oil through the bearings, so that special means are required for handling large quantities of oil. The supply for each main bearing of the motors is about 500 gals. per hour, while for the bevel gear drives of the billet mills the quantity is 15 gals. per hour for each bearing. The oil is used over and over again, which, of course, necessitates its being filtered. It travels continuously in a closed circuit; from an elevated tank it flows by gravity to the bearings and thence to a collecting tank; from this it is pumped to the filter plant, and after passing through the filters it is pumped to the elevated supply tank.

The filtering of the large quantity of oil in this lubricating system requires a special equipment, and the plant installed has a total capacity for filtering 20,000 gals. per 24 hours. The plant consists of ten filters, each having a capacity of 1,500 to 2,000 gals. per 24 hours. The filters are grouped as shown in the accompanying table, which shows also the pump and tank equipment. For this information we are indebted to the officers of the Indiana Steel Co. The lubricating system of the rail mill serves the motors only; that of the billet mill is subdivided, one part serving the motors (in two motor houses) and the other part serving the bevel gear drives for the mills. The gravity tanks for the clean oil are mounted on brackets attached to the columns of the buildings.

The filters are of the "Unit Type," made by the Burt Mfg. Co., of Akron, O., and are of special construction for this plant. There are ten filters or units, and the construction of one of these is shown in the accompanying cut. The dirty oil enters the receptacle (A) and passes through perforations into a chamber fitted with a wide and shallow settling pan. The oil spreading out in this is heated by means of a hot-water chamber underneath the pan, the chamber containing a steam pipe to maintain the heat. This preliminary heating of the oil is one of the special features of the filter system; it facilitates the depositing of grit and heavy particles, and causes the oil to flow more freely through the filter, thus increasing the speed of filtration and the capacity of the filter. The greater part of the impurities are deposited in the settling tray.

TABLE OF EQUIPMENT FOR HANDLING AND FILTERING OIL FOR THE LUBRICATION OF MOTOR BEARINGS AT THE RAIL AND BILLET MILLS OF THE INDIANA STEEL CO., GARY, IND.

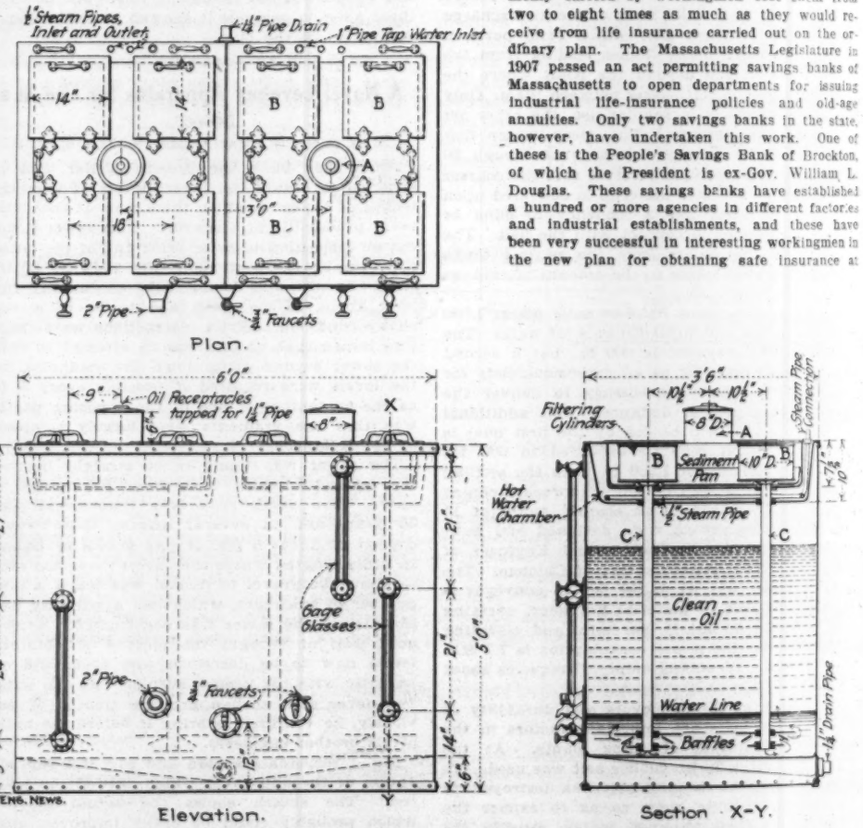
	Rail Mill.		Billet Mill.	
	No. Motor House.	So. Motor House.	No. Motor Ho. (and serving also So. House.)	For gear drives.
No. of Filters.	3	2	3	2
Combined cap. of filters for 24 hours, gals.	4,500 to 6,000	3,000 to 4,000	4,500 to 6,000	3,000 to 4,000
Motors served, No.	(3) 6,000 HP. (1) 2,000 HP.	(2) 2,000 HP.	(3) 6,000 HP. (2) 2,000 HP.	Gear drives*
Oil per hour to each bearing	500 gals.	500 gals.	500 gals.	15 gals.
Total oil handled per hour	4,000 gals.	2,000 gals.	5,000 gals.	1,100 gals.
Oil pumps (Worthington duplex piston pattern)	(3) 6 × 7½ × 6 ins.	(2) 6 × 5¾ × 6 ins.	(3) 6 × 5¾ × 6 ins.	(2) 6 × 5¾ × 6 ins.
Settling tank	48 ins. diam.	48 ins. diam.	48 ins. sq.	48 ins. sq.
Settling tank	75 ins. high	75 ins. high.	60 ins. high	60 ins. high
Clean oil gravity tank	36 ins. diam.	28 ins. diam.	36 ins. diam.	36 ins. diam.
Clean oil gravity tank	83 ft. long	73¼ ft. long	83 ft. long	27 ft. long
Height of gravity tank above floor	23 ft.	23 ft. 9 ins.	20 ft. 3 ins.	18 ft. 3 ins.

*No. of bearings for bevel gear drives: 18 for 40-in. mill, 19 for 32-in. mill, 18 for 24-in. mill, 18 for 18-in. mill.

The heated oil passes then to the filtering cylinders (B), which are of perforated metal with an exterior wrapping of filter cloth. In some cases, these cylinders have an interior filling of animal charcoal or bone black, but this is omitted in the filters for the steel works, owing to the use of the flush system of lubrication. The oil entering the cylinders passes down the vertical pipes (C), which terminate in a water bath, and here the oil receives its third cleansing by being washed as it passes up through the water into the upper or storage part of the tank. Flat and conical baffle plates on the end of each pipe cause the escaping oil to be distributed through the water in a thin film. The sediment tray can be removed for cleaning, the filter cloths are renewable, and the dirt collecting in the bottom of the tank can be blown out (with the water) through the drain pipe.

Each filter or unit has two of the oil receiving chambers (A) and eight of the filtering cylinders (B). The latter are arranged in two groups, as shown, each group serving one oil chamber and being placed in one sediment tray. The size of the filters is shown on the drawing, and the capacities of the principal parts are as follows: dirty oil chamber, 90 gals.; hot water chamber, 110 gals.; clean oil chamber, 490 gals. Gage glasses show the level of the oil and water.

It is of interest to note that this plant is considered to be one of the largest oil-filtering plants in the world. The oil filtering and lubricating plant which served the power equipment of the St. Louis Exhibition of 1904 had a maximum capacity of 2,000 gals. per hour, and was said to be the largest in use at that time. This had steam-jacketed oil filters of the "Famous" type, and was described in our issue of Sept. 15, 1904.



ONE OF THE UNITS OF THE OIL FILTERING PLANT AT THE ROLLING MILLS OF THE INDIANA STEEL CO.
(There are ten of these units.)

INDUSTRIAL INSURANCE FOR WORKMEN, on the savings-bank plan, is making progress in Massachusetts. It will be remembered that the insurance investigations of a few years ago showed that industrial insurance commonly carried by workingmen cost them from two to eight times as much as they would receive from life insurance carried out on the ordinary plan. The Massachusetts Legislature in 1907 passed an act permitting savings banks of Massachusetts to open departments for issuing industrial life-insurance policies and old-age annuities. Only two savings banks in the state, however, have undertaken this work. One of these is the People's Savings Bank of Brockton, of which the President is ex-Gov. William L. Douglas. These savings banks have established a hundred or more agencies in different factories and industrial establishments, and these have been very successful in interesting workingmen in the new plan for obtaining safe insurance at small cost. An agency recently established is at the B. F. Sturtevant Co.'s works at Hyde Park, Mass. The agency is in charge of an instructor furnished by the Savings Insurance Committee of the Boston Chamber of Commerce. The method of interesting employees is, usually, first to distribute the literature of the subject in the pay envelopes, after which the representative interviews those of the employees who desire information.

A COLLISION ON A SIDING of the Pennsylvania R. R. near Collinsville, Ill., Oct. 22, caused the death of five trainmen. A westbound freight had taken the siding to let the eastbound passenger train pass. The switch at the west end of the siding, leading back to the main track, had been left open, according to reports, by a preceding freight, but this was not noticed in time to prevent the accident. The passenger train took the switch at full speed and crashed head-on into the freight on the siding. The two locomotives and several freight cars were wrecked, the baggage and mail cars were telescoped and the express car and smoking car were derailed. Several passengers in the smoker were injured. A fire started in the wreckage of the mail car but was soon extinguished.

A BOILER EXPLOSION in the power-house of the Pabst Brewing Co., Oct. 25, caused a property loss estimated at $250,000, killed one employee and injured four others. A section of one of the walls of the power-house was blown out and the interior of the building was wrecked. Unconfirmed reports state that a part of one of the three boilers wrecked was thrown upon the roof of a three-story building across the street and that a large grain elevator nearby was jarred loose from its foundations.

A BURNING RAILWAY BRIDGE gave way under the weight of a passenger train on the Houston & Texas Central Ry., Oct. 13, near McNeil, Tex. The train left Austin at 7.30 in the morning for Llano. There was a thick fog and the engineer became aware that the bridge was on fire only when the train was close upon it. He found he could not stop before reaching the bridge and attempted to run across it. The locomotive and tender crossed safely but the baggage car and the two coaches fell with the collapsing bridge and were burned. The passengers escaped from the cars after they had fallen into the ditch. The fireman fell from the tender and was killed.

A HIGH WIND accompanied by a heavy fall of hail struck Cambridge Springs, Pa., Oct. 21. Forty buildings were damaged and 20 persons were injured. The waterworks buildings were wrecked, a part of the Riverside Hotel was torn down and seven dwelling houses were demolished. The iron bridge across French Creek was lifted from its foundations and blown into the stream.

A COAL-MINE EXPLOSION near Hartshorne, Okla., Oct. 21, in one of the mines of the Rock Island Coal Mining Co. killed twelve men. The explosion is ascribed to the ignition of gas by a miner's lamp. A dangerous amount of gas was found in a portion of the workings during the night before the accident by a fire-boss, who accordingly "dead-lined" that part of the mine pending the removal of the gas. The warning appears to have been overlooked or disregarded by the miners when they returned to work in the morning.

GAS EXPLODING IN A TUNNEL killed one man and injured several others at Santa Barbara, Cal., on Oct. 16. A long rock tunnel is being driven in the Santa Ynez mountains for the city water-supply. A blast at the heading uncovered what is thought to have been a pocket of natural gas, and when the muckers approached their open lamps ignited the gas.

A CONTRACTOR'S PROPERTY WAS DYNAMITED at Indianapolis, Ind., on Oct. 25. A barn back of his house, a telephone exchange building which he was erecting, a library building also in process of construction by him, and his planing mill, were either destroyed or injured. The four buildings were in widely separated locations, the most remote being several miles apart. The contractor recently had a difference of opinion with his union employees, who walked out when he refused to discharge his non-union men and employ only union men. The damage is estimated at from $10,000 to $15,000.

THE STATUS OF THE STEINWAY TUNNEL was litigated recently in the Court of Appeals of New York State. This tunnel, authorized by a State franchise of 1887 allowing 20 years for completion, was never begun until about five years ago, and was completed only after the first day of 1907. The city sued to have the franchise rights declared forfeited. The Court of Appeals now refuses to pass on the question, and says that the suit should be brought by the State. Some side remarks contained in the decision suggest the view that the franchise may be declared lapsed when the suit comes up in proper form. The opinion also remarks that the status of a franchise uncompleted at the stated period has never been determined in New York State.

MORE SUBWAYS IN NEW YORK CITY may be expected now, after a Court of Appeals decision defining the city's unconsumed margin of bonded indebtedness. Very urgent need for more rapid-transit lines was met by the Public Service Commission several years ago by laying out routes and drawing plans for several new subways. The city's Comptroller was opposed to their construction, on the plea that the limit of bonded debt was so nearly reached as to leave no sufficient margin for a subway. Suit brought on this plea has finally resulted in the highest State court finding that there is a large margin, which for date about a year ago amounted to nearly $55,000,000 and on the same basis amounts probably to over $100,000,000 at present. This removes the grounds alleged for the Comptroller's opposition, and if no other opposition develops in the Board of Estimate, it is probable that money for a new subway will soon be appropriated and contracts authorized.

THE PANAMA CANAL IS HALF EXCAVATED.—The grand total of Canal excavation down to the end of September was 87,172,058 cu. yds., which was only 322,479 cu. yds. short of one-half of the total excavation to be made for the completion of the Canal. As the average daily excavation is over 100,000 cu. yds., the output of the first week in October was ample to put the record safely past the halfway mark.—"Canal Record," Oct. 13.

THE FERGUS FALLS, MINN., ELECTRIC LIGHT situation took on an interesting aspect after the failure of the municipal lighting power-house and dam on Sept. 24, 1909, as recounted in Engineering News, Oct. 14, 1909, p. 393. The plant that was destroyed by undermining was owned and operated by the city and supplied all lighting of streets and public buildings. Lower down the stream was a plant, also damaged, which furnished power for the water-works pumping station. After the disaster, then, all the public services of the city were put out of commission until a temporary connection could be made to a privately-owned power plant some miles down the river from the city. Discussion immediately arose in the city council as to whether the city should set immediately to work to construct a new power station or whether it should contract for power from the private company. At this juncture matters were complicated by the company's demanding a 10-year contract or none, claiming that the expense entailed in arranging the plant for the service would not be justified for any shorter period.

This naturally caused considerable opposition in the city, but finally the company reduced its time limit to 7½ years and a contract was signed. By this contract, the city agrees to take for the next 7½ years not less than 100,000 KW.-hrs. per annum at a rate varying from 2½ to 2 cts. per KW.-hr., depending upon the amount used. Within the specified 7½ years, the city can build a plant of its own, but cannot take less than the 100,000 KW.-hrs. annually from the company, nor can it sell any of its power so developed to private interests. It was contended, in open meeting, that the cost to the city for electric power from the plant recently destroyed had been 3.1 cts. per KW.-hr., but the figures upon which this cost was based are not at all authentic.

Since the collapse of the municipal dam a diver has been sent down into the wreckage and he reported that the position of the debris would indicate that the initial failure of the dam occurred under the power-house foundation, as surmised in our article of Oct. 14. It is thought that the dam and power-house are total losses.

A GASOLINE MOTOR CAR has been purchased by the Pennsylvania R. R. for the operation of the branch line between Smyrna and Clayton, Del., 1½ miles. It is a four-wheel car, with seating accommodation for 30 passengers, and having a baggage compartment. A four-cylinder 60-HP. Fairbanks-Morse gasoline engine is used, which runs at 600 r. p. m. Gear transmission is used, with three speeds for both the forward and reverse movements. The car axle is driven by roller-chains.

HEAVY RAINFALL AT PANAMA.—At Cristobal, on the afternoon of October 8, a heavy rainfall began at 3.40 o'clock and lasted until 5.15 o'clock. In that time—1 hour and 35 minutes—6.03 ins. of rain fell. During the hour of the heaviest fall 4.90 ins. of rain were recorded. The storm was purely local to Cristobal and Colon, as at the nearest gaging station, Gatun, only 0.85 of an inch fell during the afternoon.

The heaviest rain recorded on the Isthmus was that of June 2, 1906, at Balboa, when 5.86 ins. fell in the hour from 4 to 5 o'clock in the afternoon. On Aug. 25, 1909, at Cristobal, 4.30 ins. fell between 1.56 and 2.56 o'clock in the afternoon.

The rainfall at Pedro Miguel from midnight of Sept. 30, to midnight of Oct. 9, amounted to 10.55 ins., or more than the entire precipitation at this point during the month of September, which was 10.22 ins. Two heavy storms accounted for the greater part of this rainfall, one on Oct. 1, when 3.36 ins. fell, the other on Oct. 6, when the record showed 3.82 ins.—"Canal Record," Oct 13.

A COAL TRAIN OF 7,562 TONS was hauled on the Virginian Ry. recently, says Mr. R. P. C. Sanderson (Supt. M. P.) in the "Railroad Age Gazette" of Oct. 22. The train consisted of 100 steel coal cars and a caboose, a total of 5,500 tons coal and 7,562 tons gross behind the engine. The engine was a Mikado with 24 × 32 cylinders, carrying 190 lbs. steam; it weighed 207,450 lbs. on drivers, and total with loaded tender 427,000 lbs. The trip from Victoria to Sewall's Point, 125 miles, was made in 8 hrs. 42 mins., an average speed of 14.4 mi. per hr.; this includes three stops for water.

DREDGING ON THE CAPE COD CANAL has begun. A dredge has been at work for some weeks on the Buzzards Bay entrance and on Oct. 14 a hydraulic dredge was placed in the entrance at Sandwich, the northern end of the canal.

A BLANKET BOND ISSUE of half a billion dollars for waterway improvement was opposed by President Taft in a public address at St. Louis on Oct. 25. The President approved the improvement of waterways, provided their economic utility was shown, and continued:

Let us take up each project on its merits, and determine by all means at our command whether the country in which that project is to be carried out is so far developed as to justify the expenditure of such a large sum of money and whether the project will be useful when done. When you have determined that, on the general principle of good to the entire country, then I am in favor of doing that work as rapidly as it can be done, and I am in favor of issuing bonds to do it.

A HURRICANE IN NEW ORLEANS on or about Sept. 20 caused an interruption in the operation of the pumps connected with the drainage system of that city. We are indebted to Mr. Alfred Raymond, General Manager of the Drainage Department of the Sewerage and Water Board, for the following statement of the facts in the case:

Our drainage pumps are operated by electric motors supplied with energy from a central power station, and during the storm a part of our transmission line was torn down. Some temporary wires were strung up hastily on neighboring telegraph poles and pumping was resumed within 48 hours after the cessation of the storm. The line is now being rebuilt at the point where it was torn down, with much heavier materials.

It is proposed to build a duplicate transmission line or, eventually, to place all wires underground. While the latter method is preferable, it will cost something more than half a million dollars and funds are not available for this purpose.

THE FORCED VENTILATION of street cars is now being tried by the Chicago Railways Co., according to the "Railway and Engineering Review" of Oct. 23. Some 350 of the new prepayment type of cars are being equipped with apparatus for exhausting vitiated air. A false ceiling, with 14 registers, is added and the space between the regular and false ceiling serves as an exhaust duct. A register in each vestibule also connects to the duct. A motor-driven fan placed on the vestibule roof exhausts the air from the duct. Four fresh-air intakes are cut through the floor near the sides and the air taken in through these screened openings passes through electric heaters, under the seats, before becoming free in the car.

ELECTRIFICATION OF THE ILLINOIS CENTRAL'S Chicago Terminals is discussed in the annual report to the Illinois Central stockholders as follows:

The subject of electrification of the Chicago terminals of this company has had, and is having, most earnest and thorough consideration. The problems presented are unique and complex.

There are no great freight terminals operated by electricity, and it is questionable, even aside from the great expense involved, if it is practicable. There are over 310 miles of track in the terminals, and there is a very heavy exchange of cars between this road and other roads in Chicago; to effect this exchange, it is necessary that the trains of this company shall go upon the tracks of other companies, and that their trains shall come upon our tracks; with this road alone electrified, this exchange of cars would not be practicable.

Without precedents to guide, the estimates of cost are at best unreliable; from the best obtainable information it would appear that the cost of electrifying the terminals of this company would be more than $18,000,000, a great sum to expend upon what would be of doubtful success in operation.

Earnest and painstaking investigation and consideration are being given to the subject, and pending a solution of the problem that will be satisfactory to all the interests concerned, this company is devoting great attention to reducing to a minimum the noise and smoke of its locomotives.

The Board have authorized the purchase of, and the officers are negotiating for, cars propelled by gasoline motors, and adapted for handling suburban passengers. Experiments in the use of coke as fuel for locomotives are being pursued.

IMPORTANT HIGHWAY LEGISLATION is proposed in a bill now before the British Parliament. From an outline of the bill as amended to date and reported in the London "Surveyor" of Oct. 8, it appears that a road board is to be formed under the general direction of the Treasury and with a paid chairman or vice-chairman. The powers of the road board are thus stated in the act:

To make advances to highway authorities in respect of the construction of new roads or bridges or the improvement of existing roads or bridges.

Themselves to construct and maintain any new roads and bridges connected therewith, which appear to the board to be required for facilitating road traffic.

An advance to a highway authority may be either by way of free grant or by way of loan, or partly in one way and partly in the other, and shall be upon such terms and subject to such conditions as the board think fit.

Proposals for the construction of new roads by the road board must be approved by the Treasury, but before such approval is given the Treasury must consult with the Local Government Board and must also satisfy itself

that notice of intention to construct the proposed road has been sent to all the local highway authorities along the line of the proposed road. The road board is authorized to acquire land fronting on new roads to the depth of 660 ft. from the center of the road. The board is also authorized by the act to sell, lease or manage any land thus acquired, subject to the approval of the Treasury. With like approval, the road board may borrow money for a term of years, the sum so borrowed not to exceed £200,000, or $973,000, a year. The proposed legislation is made applicable to Scotland and Ireland. An interesting general provision of the act is as follows:

In approving, executing, or making advances in respect of the execution of any work under this Act involving the employment of labor on a considerable scale, regard shall be had, so far as is reasonably practicable, to the general state and prospects of employment.

FIFTEEN MILLION DOLLARS' WORTH OF FARM products have been raised on land irrigated by the U. S. Reclamation Service this season. It is now seven years since the Reclamation Act was passed. During this period, work has been inaugurated on some thirty different projects in the arid regions of the United States, and on a considerable number of them the work has been carried to a point where a part of the lands under the project can be irrigated. Four of the projects in Montana, Wyoming and Nevada have been substantially completed. Water is now available for 768,000 acres, and of this total 425,000 acres have been purchased by settlers who are now living on the land. Not all these 425,000 acres, however, by any means contributed to the present season's crop, as many farmers have not yet prepared all of their land for water, and some of the lands were not ready for use at the opening of the crop season. There are now 343,000 acres for which water is available and which are open to settlement. The opportunities for home makers on many of these projects are so attractive, and the terms on which the lands are disposed of are so easy, the payments being distributed over a period of ten years, that it is likely that a large proportion of these lands will be taken up before the next crop season.

STREAM POLLUTION BY WOOD PULP WASTES.—Although the factories manufacturing wood pulp are located along the principal streams in Germany, yet the rivers have been practically free from pollution, owing to the strict regulations and thorough control which prevent any waste from being emptied into the rivers.

Manufacturers are required to use every precaution possible to prevent the waste reaching the streams. The water which is to be emptied into the river must leave the factory in an uninjurious and clean condition, free from any remnants from the manufacturing process. This is accomplished by passing the discharge through one or more settling ponds and, if necessary, through filters. The streams are controlled by the authorities, and any justified claim against the quality of the waters, due to pollution from the factories, is at once investigated and the condition corrected.

There are no regulations setting forth the exact method which a manufacturer must employ to prevent the pollution of the streams, as each manufacturer may carry out his own ideas upon the subject, so long as his method successfully prevents the pollution of the streams. Settling ponds are invariably used and the results are satisfactory.

The service which inspects the disposition of the waste material of factories is under the immediate jurisdiction of the county authorities and has charge of the licensing of factories.—Report by Consul W. Washington Brunswick, Chemnitz, Germany, in Public Health Reports of the U. S. Public Health and Marine Hospital Service, Oct. 15, 1909.

Personals.

Mr. Robt. S. Lovett has become President of the Union Pacific Ry., succeeding E. H. Harriman, deceased.

Mr. Daniel H. Deeter, Master Mechanic of the Philadelphia & Reading Ry. at Reading, Pa., has been appointed General Master Mechanic.

Mr. Geo. W. Daves, Signal Engineer of the Chicago & Alton R. R., has resigned to enter the service of the American Railway Supply Co., of Chicago, Ill.

Mr. C. M. Case, Chief Engineer of the Chicago, Rock Island & Gulf Ry., has resigned. He is succeeded by Mr. A. B. Warner, formerly Assistant Chief Engineer.

Mr. E. J. Noonan has been appointed Chief Engineer of the Osage Western Ry., with office at Pawhuska, Okla. This is a new railway to be built from Bartlesville, Okla., to Enid, Okla., a distance of 125 miles.

Mr. F. T. Harvard, M. Am. Inst. M. E., has been appointed Assistant Professor of mining and metallurgy at the University of Wisconsin. Mr. Harvard is a graduate of the Royal School of Mines, Freiberg, Germany.

Mr. T. W. Fathenson has been appointed District Engineer of the Choctaw district of the Chicago, Rock Island & Pacific Ry. at Little Rock, Ark., to succeed Mr. H. G. Clank, who has been assigned to other duties.

Mr. Andrew W. Woodman, M. Am. Soc. C. E., has resigned his position as Agent of the Roebling Construction Co. Mr. Woodman was Manager of the company's Boston branch for six years and has for the past four years been Manager of the western branch, with headquarters at Chicago, Ill.

Mr. W. E. Miller has been appointed Superintendent of the first division of the Denver & Rio Grande R. R., at Pueblo, Colo., to succeed Mr. F. R. Rockwell, who has been granted indefinite leave of absence on account of ill health. Mr. Miller has been for some time Acting Superintendent of this division.

As a consequence of the death of Col. Smith S. Leach, the following officers of the Corps of Engineers will be advanced in rank: Lieut.-Col. Curtis McD. Townsend, Maj. Joseph E. Kuhn, Capt. E. R. Stuart, First Lieut. C. H. Knight and Second Lieut. E. L. Daley. Upon the advancement of Col. John G. D. Knight to the rank of brigadier-general on Nov. 13, the following officers will be promoted: Lieut.-Col. Geo. W. Goethals, Maj. Wm. E. Craighill, Capt. Geo. M. Hoffman. First Lieut. Wm. A. Mitchell and Second Lieut. H. A. Finch.

Mr. Arba B. Marvin, Assistant Attorney in the patent department of the General Electric Co., at Schenectady, N. Y., for the past five years, has opened an office for general practice as a solicitor of patents at 950 Commercial National Bank Bldg., Chicago, Ill. Mr. Marvin is a graduate in electrical engineering of the University of Wisconsin and was for a time employed in the testing department of the General Electric Co. at Schenectady and was later an instructor in electrochemistry at the University of Wisconsin. He studied law at Columbian University and for two years was an examiner in the U. S. Patent Office.

Obituary.

Michael C. Doherty, Superintendent of Streets, Chicago, died Oct. 22, at the age of 43. He had held his position since 1894.

John A. Duntze, Civil Engineer of the Department of Docks and Ferries of New York City for 25 years, died Oct. 24 at his home in that city. He was born in England 55 years ago and was the son of the late Admiral Duntze of the British Navy. Mr. Duntze was a graduate of the British Military Academy at Sandhurst and at the time of his death was a member of the Royal Engineers' Society and of the Municipal Engineers of the City of New York.

Carroll F. Story, Resident Engineer in charge of the construction of the Little River water main across the Connecticut River, died Oct. 19 at a hospital in Springfield, Mass., after an illness of five weeks. Mr. Story graduated at Beloit College in 1904 and received a degree at the Massachusetts Institute of Technology in 1906. In this same year he began work in the Springfield water department. After two years' service as Engineer in charge of the Ludlow plant in Springfield, he was made Resident Engineer in charge of the Connecticut River pipe crossing in July, 1909.

Engineering Societies.

COMING MEETINGS.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Nov. 9-11. Annual convention at Little Rock, Ark. Secy., A. P. Folwell, 239 West 39th St., New York City.

NATIONAL MUNICIPAL LEAGUE.
Nov. 15-19. Annual meeting at Cincinnati, Ohio. Secy., Clinton R. Woodruff, Philadelphia, Pa.

NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS.
Nov. 16. Annual meeting at Washington, D. C. Secy., Martin S. Decker, Albany, N. Y.

AMERICAN RAILWAY ASSOCIATION.
Nov. 17. Annual meeting at Chicago, Ill. Secy., W. F. Allen, 24 Park Place, N. Y.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.
Nov. 18-19. Annual meeting at New York City. Secy., W. J. Baxter 29 West 39th St., New York City.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION.
Dec. 1-3. Annual convention at Milwaukee, Wis. Secy., James C. Monaghan, 20 West 44th St., New York City.

NEW JERSEY SANITARY ASSOCIATION.
Dec. 3-4. Annual meeting at Laurel-in-the-Pines, Lakewood, N. J. Secy., J. A. Exton, 75 Beech St., Arlington, N. J.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.
Dec. 6. Annual meeting in New York City. Secy., Wm. H. Ross, 154 Nassau St., New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Dec. 7-10. Annual meeting at New York City. Secy., C. W. Rice, 29 West 39th St., New York City.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
Dec. 8-10. Annual meeting at Philadelphia, Pa. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

ASSOCIATION OF AMERICAN PORTLAND CEMENT MANUFACTURERS.
Dec. 14-15. Annual meeting at New York City. Secy., Percy H. Wilson, Land Title Bldg., Philadelphia, Pa.

AMERICAN INSTITUTE OF ARCHITECTS.
Dec. 14-16. Annual convention at Washington, D. C. Secy., Glenn Brown, The Octagon, Washington, D. C.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.
Dec. 27. Annual meeting at Boston, Mass. Secy., L. O. Howard, Smithsonian Institution, Washington, D. C.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS.
Dec. 28-29. Annual meeting at Ames, Iowa. Secy., L. W. Chase, University of Nebraska, Lincoln, Neb.

LAKES-TO-THE-GULF DEEP WATERWAY ASSOCIATION.—The fourth annual convention will be held at New Orleans, La., Oct. 30-Nov. 2.

INSTITUTION OF MINING AND METALLURGY.—At the first ordinary general meeting of the 19th session in London, England, Oct. 21, a paper by Dr. James Douglas on "The Influence of the Railroads of the United States and Canada on the Mineral Industry" was presented for discussion.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION.—At the closing sessions of the 19th annual convention at Jacksonville, Fla., Oct. 21, officers were elected as follows: President, J. S. Lemond, Charlotte, N. C.; Vice-Presidents, H. Rettinghouse, F. E. Schall, A. E. Killian, J. N. Penwell; Secretary, C. A. Litchy, Chicago, Ill.; Treasurer, J. P. Canty. The next annual convention will be held at Fort Worth, Tex.

APPALACHIAN ENGINEERING ASSOCIATION.—At the convention to be held at Washington, D. C., Nov. 5-6, there will be addresses by W. N. Page, M. Am. Soc. C. E., Richard H. Edmonds, and Thomas L. Watson, M. Am. Inst. M. E. Papers will be presented by Professor R. L. Morris, West Virginia University; W. J. Douglas, Engineer of Bridges, District of Columbia; D. C. Weller, C.E., Engineer, Waynesboro, Pa.; E. V. N. Heermance, President, Virginia Concrete and Engineering Co., and H. Fernstrom, Chief Engineer, Virginia Ry. The second day of the convention will be devoted to an inspection of the interlocking system of the new Union Station and the concrete bridge on Connecticut Ave.

RAILWAY SIGNAL ASSOCIATION.—At the annual meeting held at Louisville, Ky., on Oct. 12 to 14, the report of the secretary showed a membership of 1,139 and a financial balance of $2,827. Several changes in the constitution were adopted. Committee reports were presented and discussed, and we have given abstracts of some of these. The election of officers resulted as follows: President, H. S. Balliet, Signal Engineer of the Electrical Division of the New York Central Ry.; Vice-President, C. C. Anthony, Assistant Signal Engineer of the Pennsylvania Ry.; Secretary and Treasurer, C. C. Rosenberg, Bethlehem, Pa. The next annual meeting will be held at Atlantic City, N. J., in October, 1910.

WESTERN SOCIETY OF ENGINEERS.—At the meeting held at the society's rooms in Chicago on Oct. 20, an exceptionally interesting address on "Recent Progress in Aviation" was given by Mr. Octave Chanute. The president, Mr. Andrews Allen, in introducing Mr. Chanute, referred to his extended investigations in aerial navigation, and to the practical proof of his early declarations in favor of the aeroplane type of air ship. The address related especially to the developments of the past few years. It was illustrated by a large number of lantern slides from engravings and photographs of various aeroplanes and aeroplane flights, beginning with the machines of Maxim, Langley, etc., and ending with those of the Wrights. These lantern-slide views were followed by a series of very interesting moving-picture views of the recent demonstrations at Rheims (France).

At a joint meeting of this society and the Chicago branch of the American Institute of Electrical Engineers, on Oct. 22, an address on "Central Station Economies" was delivered by Mr. W. L. Abbott, Chief Operating Engineer of the Commonwealth Edison Co.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—The program for the 16th annual convention at Little Rock, Ark., Nov. 9-11 includes the following papers:

Nov. 9.—Report of Committee on Municipal Data and Statistics, J. W. Howard, New York City; Report of Committee on Water-Works and Water Supply, J. L. Ludlow, Winston-Salem, N. C.; "Small Gravity Water Systems," Lucien Buck, Canton, N. C.; Report of Committee on Sewage and Sanitation, Geo. C. Whipple, New York City; "Disinfection of Sewage and Sewage Effluents," Professor Earl B. Phelps, Massachusetts Institute of Technology; "What the State of New Jersey is Doing to Purify Its Streams," H. M. Herbert, Engineer, New Jersey State Board of Health; "Refuse Disposal by High Temperature Destructor System," Wm. F. Morse, New York City.

Nov. 10.—"Some Notes on Toronto Pavements," C. H. Rust, City Engineer, Toronto, Ont.; "Pavements Without Concrete Base; Their Durability and Retention of Evenness," Paul E. Green, Division Engineer of Streets, Chicago, Ill.; "Care of Surface Water at Street Intersections," S. D. Newton, City Engineer, Knoxville, Tenn.

Nov. 11.—"Creosote Oil for Wood Block Pavements," J. N. Hazlehurst, Atlanta, Ga.; "Bituminous Pavements on Macadam Base," Linn White, Engineer, South Park Commission, Chicago, Ill.; "Three Years' Experience with Oiling Roads," F. A. Reimer, City Engineer, East Orange, N. J.